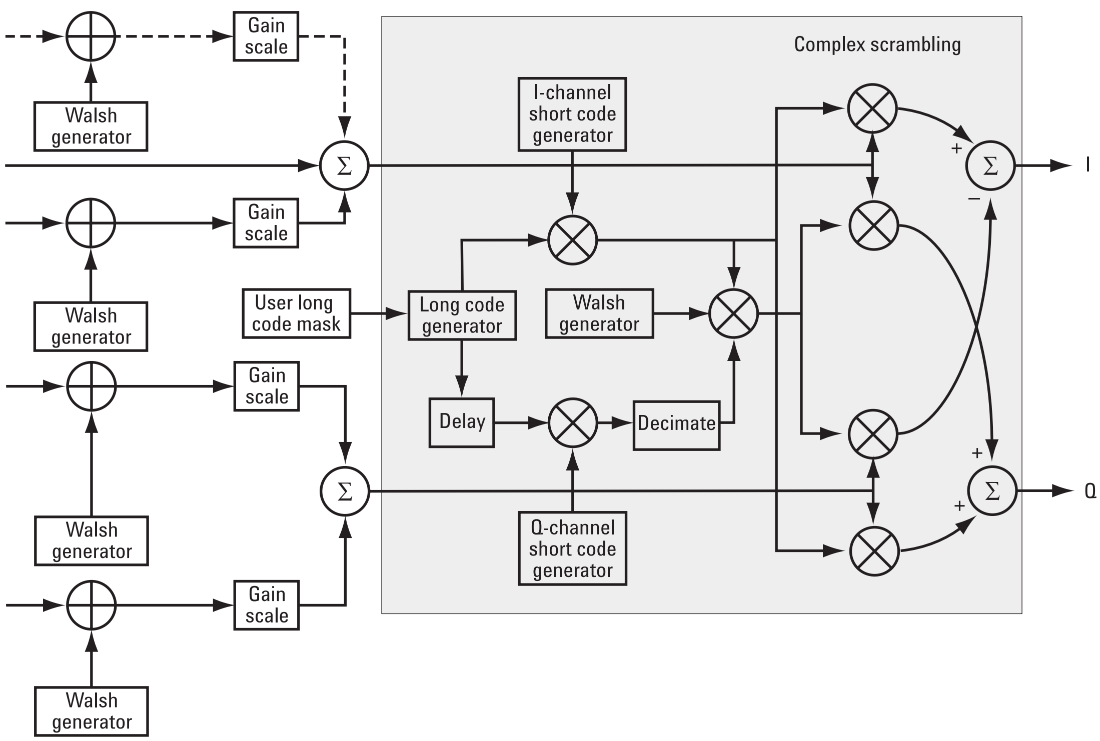
Designing and Testing cdma2000 Mobile Stations

Application Note 1358



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Introduction

One of the technologies meeting the IMT-2000 requirements for a third generation (3G) global wireless communications system is cdma2000, also known as IS-2000[1]. The Third-Generation Partnership Project 2 (3GPP2) is implementing this wideband CDMA system as a derivative of the IS-95B CDMA system, also known as cdmaOne. The 3GPP2 organizational partners are the Japanese Association of Radio Industries and Businesses (ARIB), Telecommunication Technology Committee (TTC), Telecommunications Industries Association (TIA), and Korean Telecommunications Technology Association (TTA).

As the IS-2000 specifications are finalized, the first mobile station designs are being completed and tested. This application note describes mobile station (MS) design and measurement issues at the physical layer (layer 1) that may differ between cdma2000 and cdmaOne. Although it focuses on the last stages of MS development, it is also useful for engineers working in the early stages of manufacturing. The application note also provides a list of Agilent Technologies' cdma2000 solutions for these areas.

This application note assumes that you are familiar with cdmaOne measurements and technology basics. cdmaOne is used as a reference throughout this application note. The main differences between cdmaOne and cdma2000 systems and the corresponding design and measurement implications are highlighted. For more information on cdmaOne measurements see **[1]**.

This application note can be downloaded from the web and printed locally: **http://www.agilent.com/find/3G** (under "Technical Papers").

1. IS-2000 is the Telecommunications Industries Association's (TIA's) standard for 3G technology that is an evolution of the cdmaOne code-division-multiple-access (CDMA) format. cdma2000, which is often used interchangeably with IS-2000, is also used to refer to the access format and system.

1 Basic concepts of cdma2000

The main advantages that cdma2000 offers over other IMT-2000 proposals are backward compatibility with cdmaOne systems and a smooth migration from second-generation (2G) cdmaOne systems to 3G. Figure 1 shows a possible evolution from cdmaOne to cdma2000 systems.

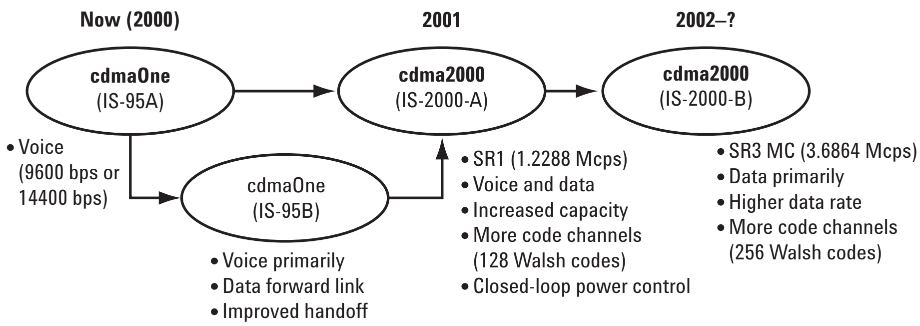


Figure 1. Evolution from cdmaOne to cdma2000

1.1 Spreading rate

Spreading rate (SR) defines the final spread chip rate in terms of 1.2288 Mcps. The two spreading rates are SR1 and SR3.

SR1: A SR1 signal has a chip rate of 1.2288 Mcps and occupies the same bandwidth as cdmaOne signals. The SR1 system doubles the system capacity. Therefore, it can be considered an improved cdmaOne system. The main differences from cdmaOne are

- fast power control and Quadrature Phase Shift Keying (QPSK) modulation rather than dual Binary Phase Shift Keying (BPSK) in the forward link
- pilot signal, to allow coherent demodulation, and Hybrid Phase Shift Keying (HPSK) spreading in the reverse link

SR3: A SR3 signal has a rate of 3.6864 Mcps (3 x 1.2288 Mcps) and occupies three times the bandwidth of cdmaOne. The SR3 system incorporates all the new coding implemented in a SR1 system and supports higher data rates. It is designed to allow SR3 signals to be directly overlaid on top of existing cdmaOne systems. To achieve an overlay system, the SR3 forward link breaks up the data into three carriers, each of which is spread at 1.2288 Mcps (see figure 2). For this reason, the system is known as SR3 MC (multi-carrier). The reverse link uses a single carrier spread at 3.6864 Mcps.

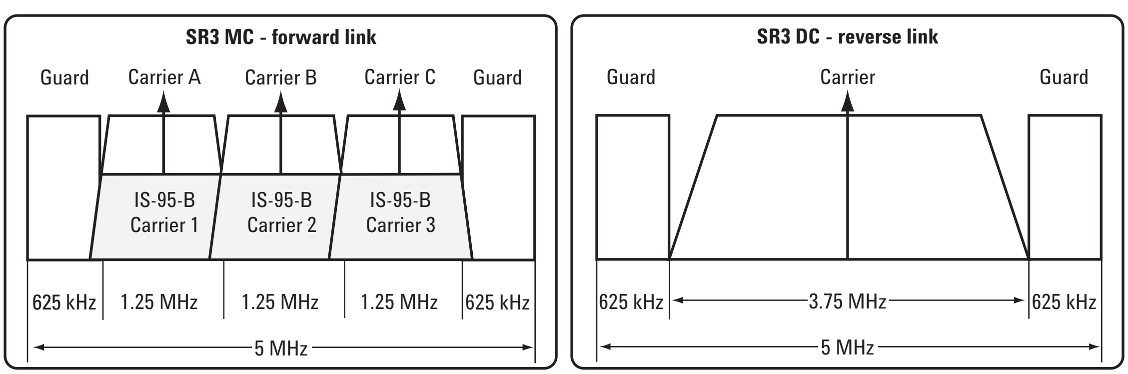


Figure 2. Bandwidth limits for SR3 MC (forward and reverse links)

1.2 Radio configuration

Radio configuration (RC) defines the physical channel configuration based upon a specific channel data rate. Each RC specifies a set of data rates based on either 9.6 or 14.4 kbps. These are the two existing data rates supported for cdmaOne. Each RC also specifies the spreading rate (either SR1 or SR3) and the physical coding. Currently there are nine radio configurations defined in the cdma2000 system for the forward link and six for the reverse link. For example:

- RC1 is the backwards compatible mode of cdmaOne for 9600-bps voice traffic. It includes 9.6, 4.8, 2.4, and 1.2 kbps data rates and operates at SR1. It does not use any of the new cdma2000 coding improvements.
- RC3 is a cdma2000 specific configuration based on 9.6 kbps that also supports 4.8, 2.7, and 1.5 kbps for voice, while supporting data at 19.2, 38.4, 76.8, and 153.6 kbps. It operates at SR1.

Each base station (BS) or MS must be capable of transmitting using different radio configurations at the same spreading rate. Refer to **[2]** for detailed information on the different RCs.

1.3 Forward link air interface

The forward link air interface for a cdma2000 SR1 channel is very similar to that of cdmaOne. In order to preserve compatibility, cdma2000 uses the same structure as cdmaOne for the Forward Pilot (F-Pilot), Forward Sync (F-Sync), and Forward Paging (F-Paging) channels.

In cdma2000, each user is assigned a Forward Traffic (F-Traffic) channel, which consists of

- one Forward Fundamental Channel (F-FCH)
- zero to seven Forward Supplemental Code Channels (F-SCHs) for RC1 and RC2
- zero to two Forward Supplemental Channels (F-SCHs) for RC3 to RC9

The F-FCHs are used for voice and the F-SCHs are used for data. The BS may also send a number of Forward Dedicated Control Channels (F-DCCHs). An F-DCCH is associated with traffic channels (either FCH or SCH) and may carry signaling data and power control data.

One of the main differences between cdmaOne and cdma2000 is that the latter uses true QPSK modulation (as opposed to dual-BPSK) for all traffic channels from RC3 to RC9. As an example, figure 3 shows the forward link structure for an RC4 F-FCH. The coding is identical to cdmaOne up through the long code scrambling of the voice data. The F-FCH is optionally punctured with the reverse link power control data bits. The data is then converted from a serial bit stream into a 2-bit wide parallel data stream to produce true QPSK modulation. This reduces the data rate of each stream by a factor of two. Each branch is spread with a 128 Walsh code to generate a spreading rate of 1.2288 Mcps. In this case, the processing gain is doubled for each channel relative to cdmaOne. Each channel is transmitted at one-half the power used before, but there are now two of them for no apparent gain. The actual processing gain for each channel depends on its data rate and RC.

The outputs of the I and Q Walsh spreaders are then complex multiplied against the same I and Q channel short codes used in cdmaOne. Complex scrambling is used in the forward link instead of regular scrambling because it facilitates the receiver descrambling process.

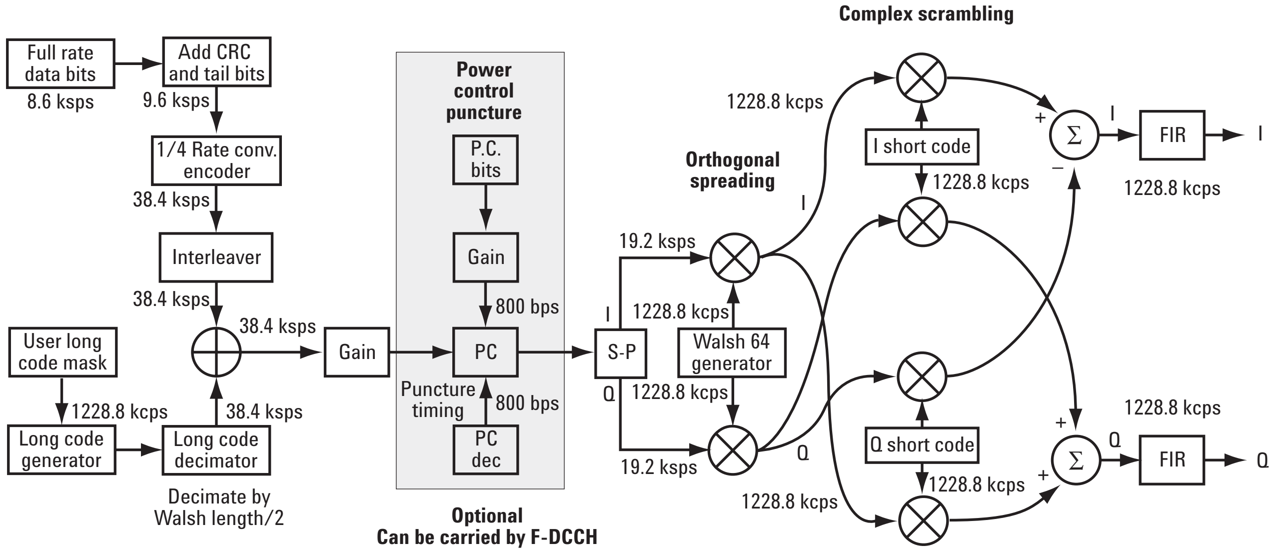


Figure 3. Coding and air interface for a cdma2000 RC4 F-FCH

1.4 Reverse link air interface—HPSK

The cdma2000 reverse link is very different from cdmaOne. The MS can transmit more than one code channel to accommodate the high data rates. The minimum configuration consists of a Reverse Pilot (R-Pilot) channel to allow the base station to perform synchronous detection and a Reverse Fundamental Channel (R-FCH) for voice. Additional channels, such as the Reverse Supplemental Channels (R-SCHs) and the Reverse Dedicated Control Channel (R-DCCH) can be used to send data or signaling information, respectively.

The different channels are assigned to either the I or Q path. For example, for RC3 to RC6, the R-Pilot is assigned to I and R-FCH is assigned to Q (see figure 4).

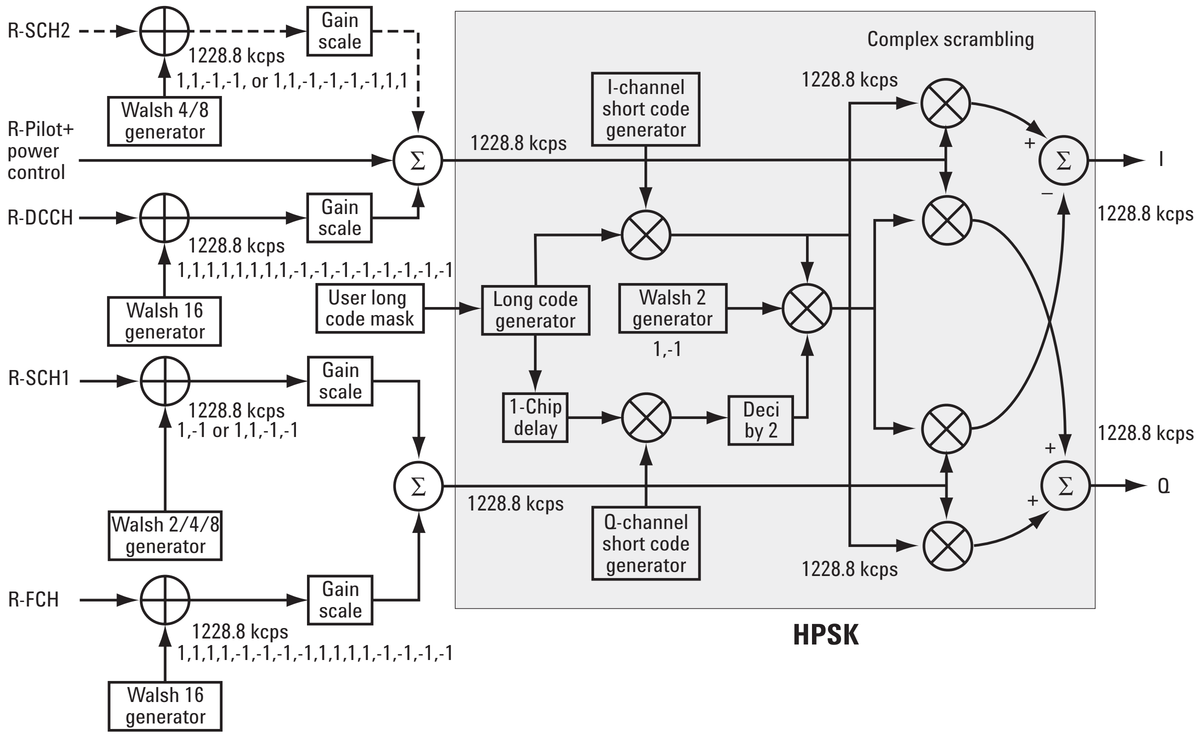


Figure 4. An example of channel summing and HPSK spreading in cdma2000 reverse link (SR1). The SR3 mode has the same reverse link structure. The only difference is that for SR3 the final spreading rate is 3.6864 Mcps.

Channels can be at different rates and different power levels. Complex scrambling facilitates this by continuously phase rotating the constellation and thus distributing the power evenly between the axes.

Without scrambling, unequal channel powers would result in a rectangular 4-quadrature amplitude modulation (QAM) constellation (assuming that only R-Pilot and R-FCH are active). With complex scrambling, the constellation for two channels generally has eight points distributed around a circle, with the angular distribution determined by the relative powers of the two channels. For example, an amplitude difference of 6 dB between the two channels results in the constellation shown in figure 5, which is close to an 8-PSK (8-Phase Shift Keying) constellation (an amplitude difference of 7.65 dB would result in a perfect 8-PSK constellation). If the amplitudes for the two channels are equal, then pairs of constellation points merge to give a QPSK-like constellation.

I/Q measured polar vector

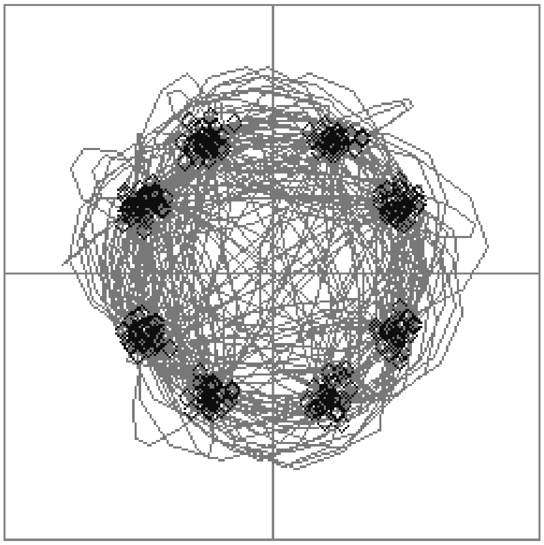


Figure 5. A reverse link cdma2000 SR1 signal with a R-Pilot and a R-FCH. The amplitude of the R-FCH is 6 dB lower than that of the R-Pilot.

Basic complex scrambling applies a phase rotation of 0, ±π/2, or π radians to each chip. HPSK takes this idea a stage further and defines the complex scrambling so that for every second chip, the phase rotation is restricted to ±π/2. This constraint on the phase transitions entering the baseband pulse shaping filter reduces the peak-to-average ratio of the signal (about 1 to 1.5 dB) compared to regular complex scrambling (or regular QPSK). The HPSK technique continues to be advantageous even when the signal has more than two channels. For more information on HPSK see **[3]**.

1.5 Forward link power control

A key improvement in cdma2000 is forward link power control. The MS sends power control data back to the BS by time multiplexing it with the R-Pilot channel. Like the existing reverse link closed loop power control of cdmaOne, the cdma2000 forward link closed loop power control sends 800 power control bits each second. These bits indicate whether the BS should raise or lower its power in 1 dB, 0.5 dB, or 0.25 dB. The finer steps allow tighter power control for low mobility or stationary phones. Tighter control (less power ripple) lowers the average power and thus raises the capacity of the system.

1.6 Differences between cdma2000 and W-CDMA

The Third-Generation Partnership Project (3GPP) W-CDMA is the other main wideband CDMA technology competing for the 3G cellular market. There has been much discussion about the need to harmonize W-CDMA and cdma2000 in an attempt to facilitate global use of 3G phones. However, even though both systems are based in a similar CDMA technology, they are significantly different. The main differences are

- the spreading rate (3.84 Mcps for W-CDMA versus 3.6864 Mcps for cdma2000 SR3)
- the synchronization and BS identification methodology (W-CDMA does not use GPS)

For information on W-CDMA User Equipment (UE)[1] design and test issues, please refer to **[4]**.

1. The W-CDMA specifications use the term UE to refer to mobile phones, wireless computing devices, or other devices that provide wireless access to the W-CDMA system.

2. Design and measurement issues

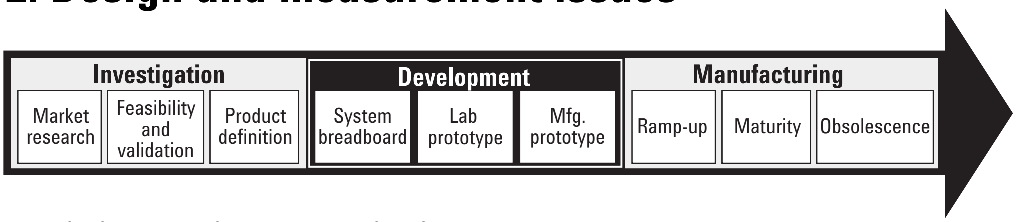


Figure 6. R&D and manufacturing phases of a MS

Figure 6 shows a generic diagram for the R&D and manufacturing phases of a MS. This chapter focuses on the development phase of the MS, highlighted in black. However, it contains general information useful to engineers involved in any area of the MS life cycle.

This chapter describes design and measurement issues that you may encounter when designing and testing cdma2000 MS, in contrast to cdmaOne. Although the exact cdma2000 measurement specifications are not finalized, in general we can assume that, when possible, the basic measurement methodology will be similar to cdmaOne. Therefore, in this section cdmaOne measurements are used as a reference. For information on cdmaOne measurements refer to **[1]**.

Refer to appendix B for a list of Agilent solutions available for MS design and test.

2.1 Maximizing battery life

Long battery life is a key competitive advantage for the mobile phone. cdmaOne uses Offset Quadrature Phase Shift Keying (OQPSK) as the modulation format for the reverse link. OQPSK minimizes the peak-to-average power ratio by avoiding signal envelope transitions through zero. Peak-to-average power ratio is the ratio of the peak envelope power to the average envelope power of a signal. If the peak-to-average power ratio is small, the headroom required in the amplifier to prevent compression of the signal and interference with the adjacent frequency channels is small. Thus, the amplifier can operate more efficiently.

In cdma2000 the handset can transmit multiple channels to accommodate the high data rates. Modulation schemes such as OQPSK or Gaussian Minimum Shift Keying (GMSK) do not prevent zero-crossings for multiple channels and are no longer suitable. Instead, QPSK is used in combination with HPSK to minimize the peak-to-average power ratio. (For more information on HPSK see **[3]**.) With this technique, the peak-to-average power ratio for the basic configuration (a Reverse Pilot Channel and a Reverse Fundamental Channel) is equal or larger than 4 dB during 0.1 percent of the time (see figure 7). Even though HPSK reduces the peak-to-average power ratio, it still increases as code channels are activated for higher data rates because the amplitude vectors of each code channel add to each other. The worst case will be if two supplemental channels at high data rates are required. In this case, the benefits of HPSK may be lost (see section 2.2.3). This is rarely expected to happen since the forward link will carry most of the high data rate traffic.

The amplifier must be capable of handling the different peak-to-average power ratios the signal exhibits for the different channel configurations, while maintaining a good adjacent channel power (ACP) performance.

From the measurement perspective, the statistics of the signal may impact the result of the measurement, particularly in the case of adjacent channel power ratio (ACPR). Therefore, it is important to choose the signal's channel configuration carefully. You need to cover the real-life worst cases, such as those with the most stressful signal configurations or highest peak-to-average power ratios. To do that, you need a way to define the statistics of cdma2000 reverse link signals. The complementary cumulative distribution function (CCDF) does that for you.

2.1.1 CCDF

The CCDF fully characterizes the power statistics of the signal **[5]**. It provides the distribution of particular peak-to-average power ratios versus probability.

Figure 7 compares the CCDF curves for a signal with R-Pilot and R-FCH, and a signal with R-Pilot, R-FCH, R-SCH1 at 153.6 kbps, and R-SCH2 at 153.6 kbps. For a probability of 0.1 percent, the signal with two supplemental channels has a peak-to-average power ratio 2 dB higher than the signal with only a R-Pilot and a R-FCH. As mentioned earlier, adding code channels, in general, increases the peak-to-average power ratio of the signal **[5]**.

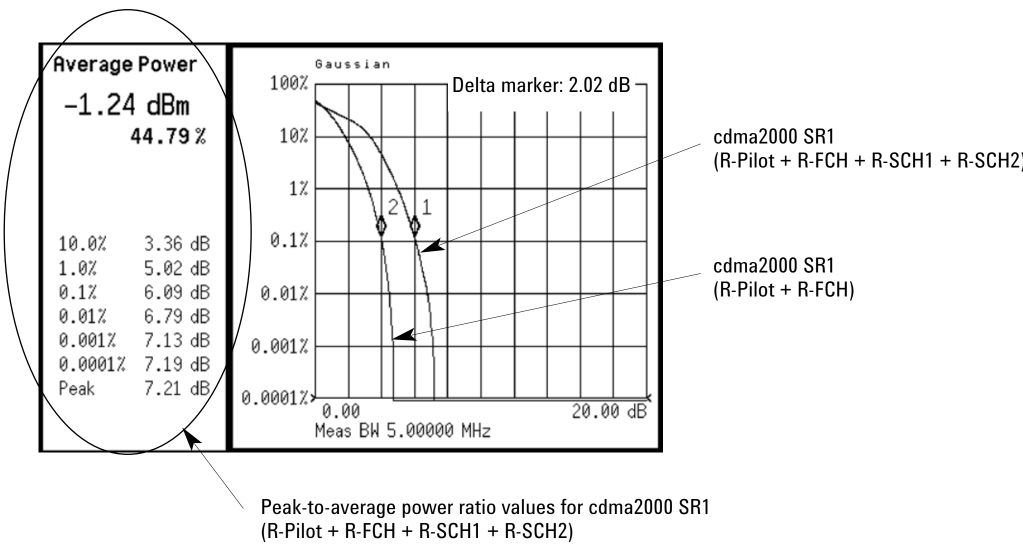


Figure 7. CCDF curves for two cdma2000 SR1 reverse link signals with different channel configurations

So, how do the statistics of cdmaOne compare to the statistics of cdma2000? Figure 8 shows the CCDF for a cdmaOne reverse link signal and the CCDF for a cdma2000 signal with a R-Pilot and a R-FCH. At 0.1 percent the peak-to-average power ratio of the cdma2000 SR1 signal is 0.5 dB lower than the cdmaOne signal.

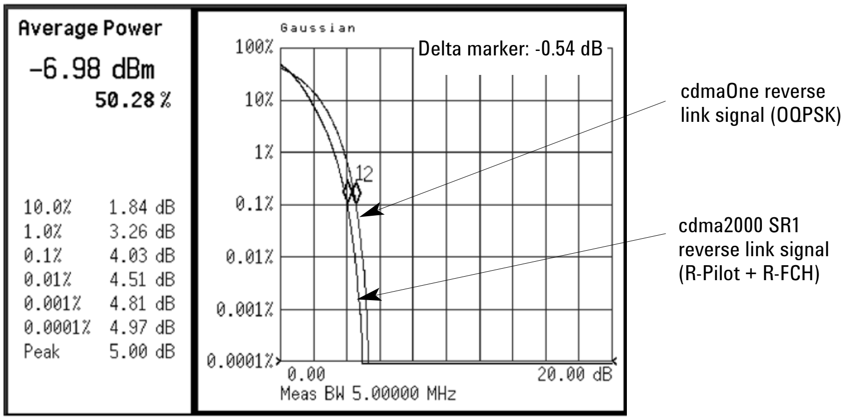


Figure 8. CCDF comparison between cdmaOne and cdma2000 reverse link signals

CCDF curves can help you in several situations:

- Determining the headroom required when designing a component. You can do this by correlating the CCDF curve of the signal with the amplifier gain plots **[5]**.
- Confirming the power statistics of a given signal or stimulus. CCDF curves allow you to verify if the stimulus signal provided by another design team is adequate. For example, RF designers can use CCDF curves to verify that the signal provided by the Digital Signal Processing (DSP) section is realistic.
- Confirming the component design is adequate or troubleshooting your subsystem or system design. You can make CCDF measurements at several points of the system design. For example, if the ACPR of the transmitter is too high, you can make CCDF measurements at the input and output of the power amplifier. If the amplifier design is correct, the curves will coincide. If the amplifier compresses the signal, the peak-to-average power ratio of the signal will be lower at the output of the amplifier.

2.1.2 ACPR

The ACPR is usually defined as the ratio of the average power in the adjacent frequency channel (or offset) to the average power in the transmitted frequency channel. The ACPR measurement is not part of the cdmaOne standard, however, individual network equipment manufacturers typically specify ACPR as a figure of merit for component testing **[1]**.

As mentioned earlier, when testing ACPR it is important to take into account the power statistics of the signal. A signal with a higher peak-to-average ratio may cause more interference in the adjacent channel. Thus, ACPR measurements can provide different results depending on the signal configuration. The safest approach is to select at least one high-stress cdma2000 stimulus signal and test with various combinations of channels.

The appropriate ACPR measurement parameters for cdma2000 depend on the spreading rate (SR). For SR1, you can use the cdmaOne parameters since cdmaOne and cdma2000 both use the same chip rate and filtering. Figure 9 shows the ACPR measurement for a cdma2000 SR1 reverse link signal.

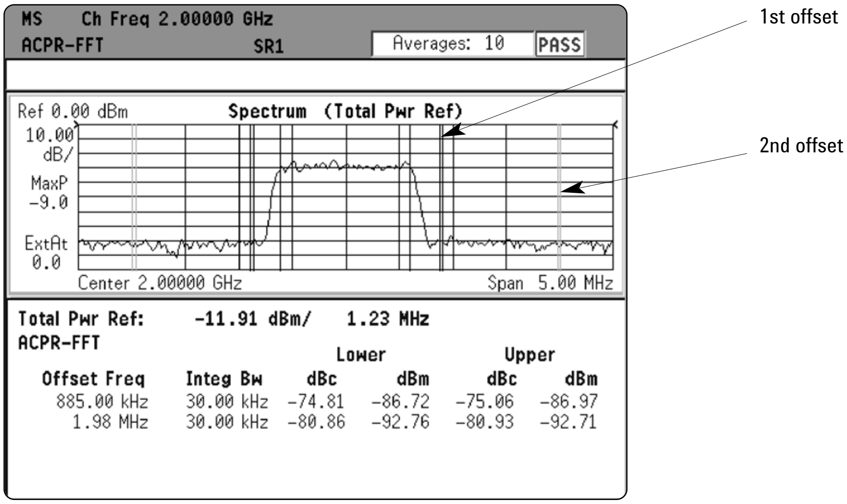


Figure 9. ACPR measurement for a cdma2000 SR1 reverse link signal

The IS-2000 standard may incorporate, for Band Class sox, the adjacent channel leakage ratio (ACLR) specifications equivalent to those used in W-CDMA. This would make cdma2000 MS compliant with the regulations that ensure compatibility of the 3G standards in Europe. The ACLR requirements provide sufficient protection of neighboring channels used by different operators. The concept of ACLR is similar to that of ACPR. ACLR is defined as the ratio of the transmitted power in the assigned CDMA channel to the transmitted leakage power in a neighboring band for a given frequency offset and bandwidth. The adoption of this test in the IS-2000 standard and its exact specifications are currently under debate.

2.2 Measuring modulation accuracy

Measuring modulation accuracy for cdma2000 MS is more complex than for cdmaOne MS. Since the cdma2000 MS can transmit several channels, think of it as a miniature BS. It requires the same kind of tests (code domain analysis, etc.) you would perform on any CDMA BS.

There are many measurements available to analyze the modulation accuracy of a cdma2000 MS transmitter: rho (pilot-only), QPSK error vector magnitude (EVM), composite rho and EVM, code domain power, symbol EVM per code channel, etc. Apart from their basic algorithm these measurements differ mainly on three aspects:

- whether you can use them to analyze a signal with a single (QPSK EVM) or multiple (composite rho, code domain power, symbol EVM) code channels
- if you can use them to analyze multi-channel signals, whether they provide information about each channel (code domain power, symbol EVM) or about the overall signal with no differentiation between channels (composite rho)
- how (what degree of demodulation) and at what level (chip, symbol) the reference is computed

The best measurement to use depends on the design stage and the test purpose. In general, these measurements can complement each other by providing additional pieces of information. The following sections intend to clarify what information these measurements provide and when to apply them.

2.2.1 QPSK EVM

In digital communication systems, signal impairment can be objectively assessed by looking at the constellation and taking the displacement of each measured dot from the reference position as an error phasor (or vector), as shown in figure 10.

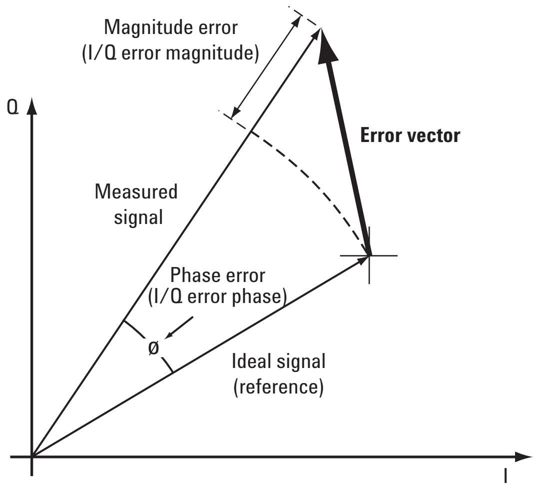


Figure 10. Error vector and related parameters

The reference position is determined from a reference signal that is synthesized by demodulating the received signal to symbols and then remodulating these symbols "perfectly". For example, figure 11 shows how the ideal reference is calculated for a QPSK signal.

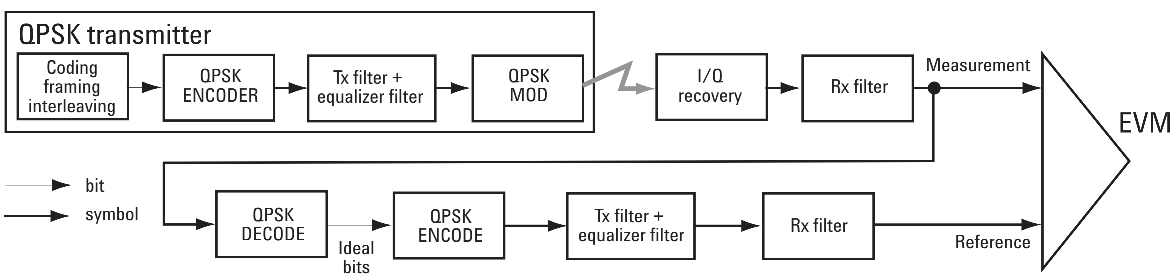


Figure 11. Process to calculate EVM for a QPSK signal

The root mean square (RMS) of the error vectors is computed and expressed as a percentage of the overall signal magnitude. This is the error vector magnitude (EVM). EVM is a common modulation quality metric widely used in digital communication systems. (See **[6]** for more information on how to use EVM as a troubleshooting tool.)

For a regular QAM or a PSK signal the ideal symbol points always map onto a few specific locations in the I/Q plane. The cdma2000 reverse link signal can consist of multiple channels that are I/Q multiplexed. This means the bits for each channel are BPSK encoded[1] for either the I or the Q path. Several channels can be added to the I and/or the Q paths. The resulting I and Q signals are then spread and HPSK scrambled (see figure 4). The complex-valued chip sequence is then filtered and the result is applied to the QPSK modulator[2]. The cdma2000 MS transmitter in figure 12 illustrates this process.

1. BPSK encoding, in this case, refers to the process of mapping the bits for a channel onto the I (or the Q) path in serial. This means the bits for a channel are directly converted into I (or Q) levels. For example, 1001 would be converted to 1 -1 -1 1.

2. QPSK modulation, in this case, refers to the upconversion process (the process of modulating the RF carrier with the I/Q baseband signal.

The resulting constellation depends on the physical channel configuration. The constellation typically does not look like QPSK or any other known constellation. Except for some very specific channel configurations, for example, a signal with a single R-Pilot (or a single R-FCH) does map onto a QPSK constellation. A signal with both a R-Pilot and a R-FCH at the same amplitude level maps onto a 45°-rotated QPSK constellation **[3]**. Since the receiver does not care about the absolute phase rotation, it effectively sees a QPSK constellation.

You can use a regular QPSK EVM measurement to evaluate the modulation quality of the transmitter for a single R-Pilot, a single R-FCH, or a signal with both at the same amplitude level. More complex signals cannot be analyzed with this measurement.

The signal analyzer may use either of the following methodologies to make a QPSK EVM measurement:

1. **Measure QPSK EVM on the received signal.** Filter the recovered I/Q signal with the equalizer and complementary receiver filters and compare it with a reference signal calculated by filtering the demodulated signal with the transmitter, equalizer, and receiver filters (figure 12a).
2. **Measure QPSK EVM on the transmitted signal.** Compare the I/Q recovered signal directly with a reference signal calculated by filtering the ideal bits with the transmitter filter (figure 12b).

Both methods yield similar EVM results and you can use either of them to make valid modulation quality measurements of the base station transmitter; however, the resulting constellation looks different. The first method results in four discreet constellation points. The second method results in a fuzzy constellation, as shown in Figure 13a. The constellations for both methods are correct. The reason for the difference is that, for the first method, the constellation displays what the receiver sees after filtering, while the second method displays the constellation of the transmitted signal before applying any receiver filtering.

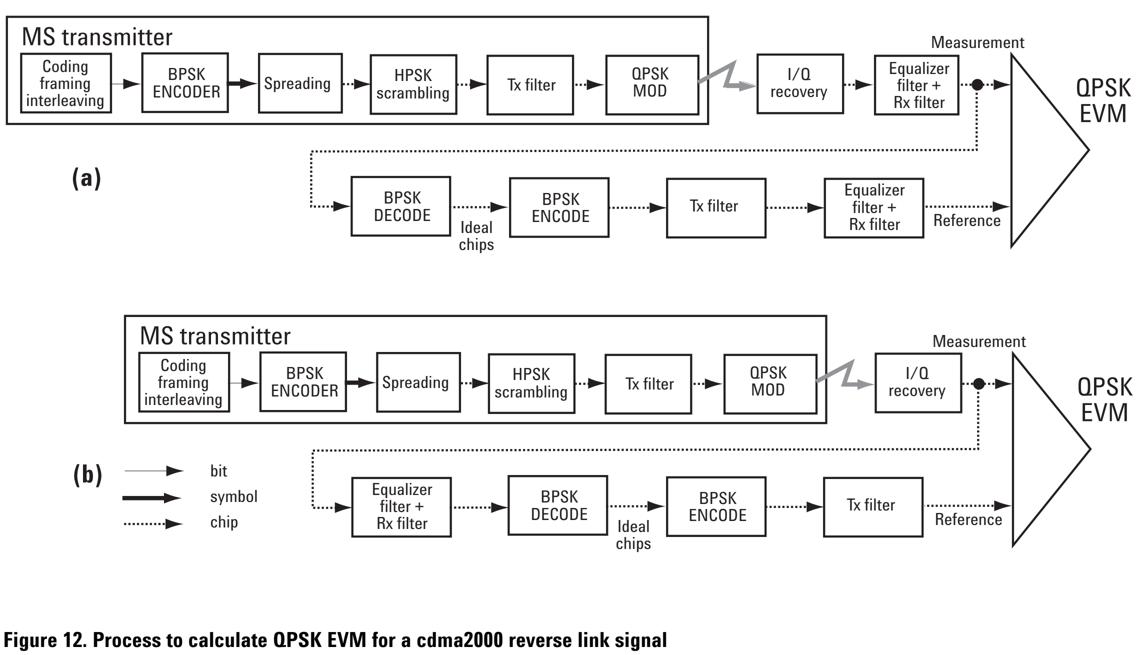
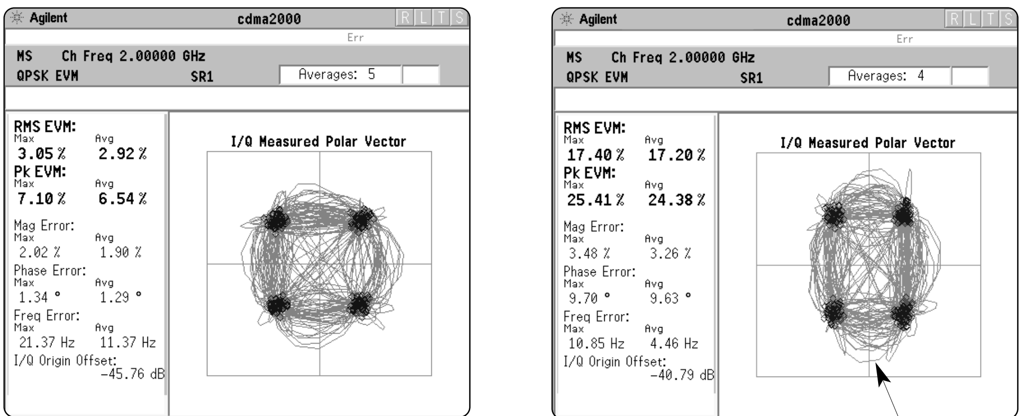


Figure 12. Process to calculate QPSK EVM for a cdma2000 reverse link signal

In any case, QPSK EVM does not descramble and despread the signal into bits and back into chips to calculate the appropriate reference. Therefore, it can detect baseband filtering, modulation, and IF and RF impairments, but does not detect spreading or scrambling errors.

If it is impossible to despread or descramble the signal, the QPSK EVM measurement may be the only choice. In this sense, the QPSK EVM measurement can be useful to RF designers or system integrators to evaluate the modulation quality of the analog section of the transmitter when the spreading or HPSK scrambling algorithms are not available or do not work properly. For example, figure 13 shows a QPSK EVM measurement for a single R-Pilot for a transmitter with and without an I/Q gain problem.



(a) (b)

Constellation distorted by I/Q gain imbalance

Figure 13. QPSK EVM on a cdma2000 reverse link signal with a single R-Pilot channel, (a) without any impairments, and (b) with an I/Q gain impairment

You can use the vector diagram, error vector versus time or frequency, magnitude error and phase error versus time to troubleshoot the impairment. For example, most I/Q impairments (such as the I/Q gain error in figure 13b) can be easily recognized by looking at the vector diagram, while in-channel spurious can be detected by analyzing the error vector spectrum **[6]**.

2.2.2 Composite rho

In cdma2000, as in cdmaOne, the specified measurement for modulation accuracy is rho. Rho is the ratio of the correlated power to the total power. The correlated power is computed by removing frequency, phase, and time offsets and performing a cross-correlation between the corrected signal and an ideal reference.

In cdmaOne, the rho measurement is performed on the reverse link signal that consists of a single channel. In cdma2000, the rho measurement will probably be defined either for a signal with a R-Pilot only or for a signal with a R-Pilot and a R-FCH.

In practice, you can perform a rho measurement on any cdma2000 reverse link signal, regardless of the channel configuration. For this reason, the measurement is usually called composite rho. Composite rho allows you to verify the overall modulation accuracy for a transmitter, regardless of the channel configuration, as long as a R-Pilot is present. The measurement algorithm involves descrambling and despreading the measured signal to calculate the reference signal, as shown in figure 14.

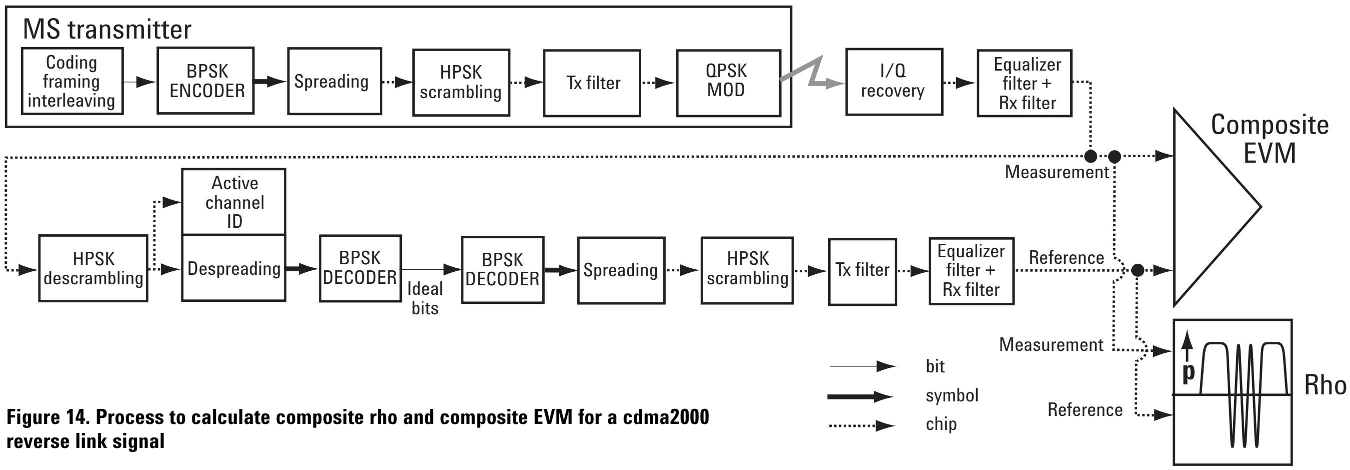


Figure 14. Process to calculate composite rho and composite EVM for a cdma2000 reverse link signal

A composite rho measurement accounts for all spreading and scrambling problems in the active channels and for all baseband, IF, and RF impairments in the transmitter chain. However, unless combined with a constellation diagram and other modulation accuracy measurements, rho (or composite rho) does not help you identify the cause of the error. Figures 15a and 15b show composite rho combined with one of these measurements (composite EVM) and the constellation for a signal with a R-Pilot and a R-FCH and a signal with a R-Pilot, R-FCH, and one R-SCH, respectively.

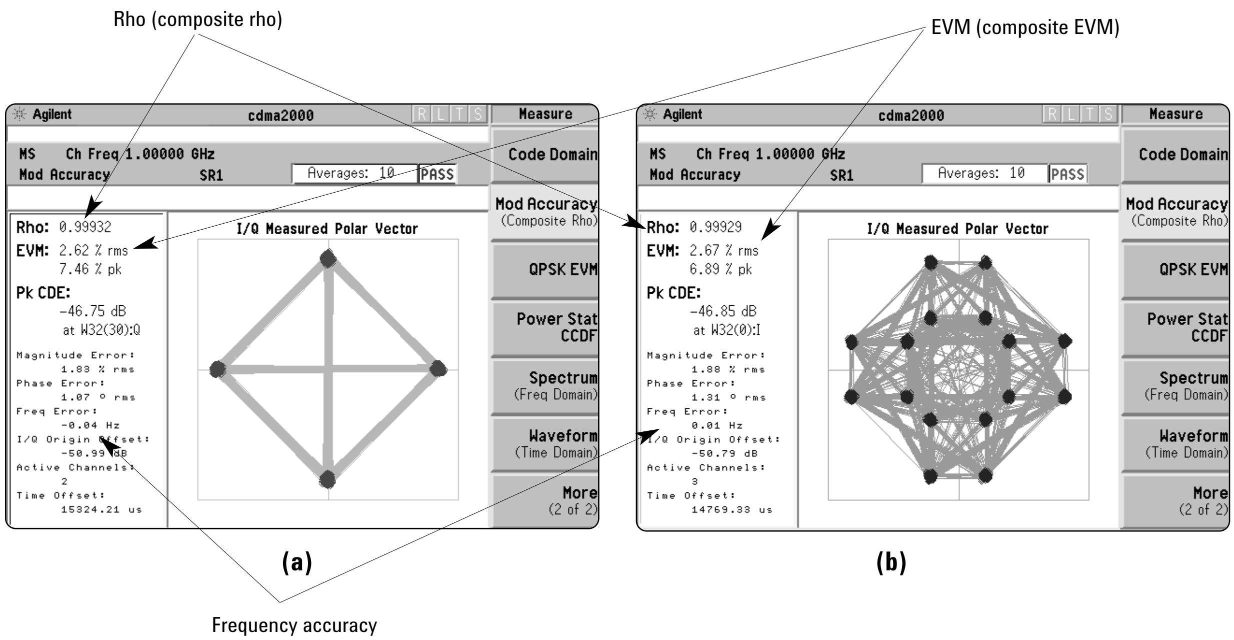


Figure 15. Composite rho measurement for (a) a cdma2000 SR1 reverse link signal with a R-Pilot and a R-FCH, and (b) a cdma2000 SR1 signal with a R-Pilot, a R-FCH and one R-SCH (the R-FCH is 3 dB lower than the other two channels)

Like QPSK EVM, composite EVM calculates the error vector difference between the measured and the ideal signal. The difference is that composite EVM uses the same reference as composite rho—that is, it descrambles and despreads the measured signal to calculate the reference (figure 14).

By performing a composite rho or composite EVM test, you also obtain a measure of the frequency accuracy (see figure 15), required in cdmaOne and in the IS-2000 standard.

Here are some situations in which you should use composite rho (and composite error vector measurements) instead of a QPSK EVM measurement:

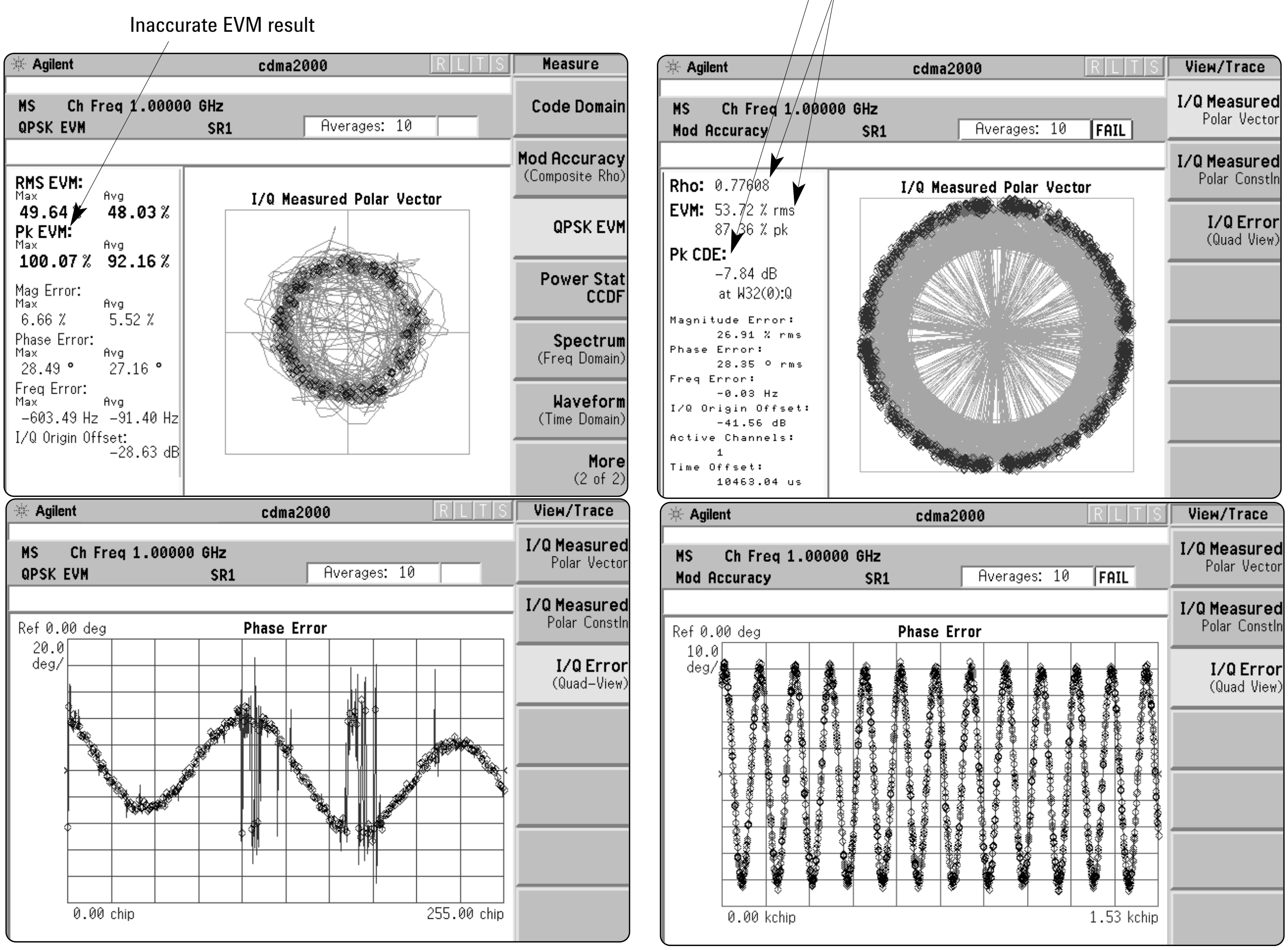
- **To evaluate the quality of the transmitter for a multi-channel signal.** This is particularly important for RF designers who need to test the RF section (or components) of the transmitter using realistic signals with correct statistics. As mentioned earlier, in general, the peak-to-average power ratio of the signal increases as the number of channels increases. By measuring modulation quality on a multi-channel signal, you can analyze the performance of the RF design for cdma2000 reverse link signals with different levels of stress (different CCDFs). Evaluating the modulation quality of multi-channel signals is also important for the baseband designers to analyze the performance of multi-board baseband designs. For example, a small timing error in the clock synchronization between channels on different boards can be detected as a decrease in modulation quality.

- **To detect spreading or scrambling errors.** Depending on the degree of the error, the analyzer may show an intermittent unlock condition or may not be able to lock at all when trying to perform a composite rho measurement. These conditions are mainly of interest to system integrators to determine errors in the spreading and scrambling. Should this problem occur, you can use the QPSK EVM measurement to confirm the rest of the transmitter is working as expected. If the scrambling or spreading error does not cause an unlock measurement condition, you can use the error vector versus time display to find the problematic chip.

- **To detect certain problems between the baseband and RF sections.** Again, these cases are mainly of interest to system integrators. You may be able to use the QPSK EVM measurement to detect some of these problems. For example, LO instability caused by interference from digital signals can be detected with QPSK EVM. However, the QPSK EVM measurement will not detect problems that require synchronization with the signal. For example, I/Q swapped errors will look perfectly normal if a QPSK EVM measurement is used. On the other hand, it will cause an unlock condition when performing a composite rho measurement.

- **To analyze errors that cause high interference in the signal.** If the interference is too high, the QPSK EVM measurement may not be able to recover the true ideal reference. In this case, the QPSK EVM and its related displays are not accurate. Since the composite rho measurement descrambles and despreads the signal, it takes advantage of the signal's processing gain. This allows the analyzer to recover the true reference even when the signal is well beyond the interference level that will cause multiple chip errors. Therefore, composite rho and composite EVM are true indicators of modulation fidelity even when the signal under test is buried by interference. In this sense, these measurements may be particularly useful in hostile field environments with high levels of interference. System integrators can use the composite EVM measurement to analyze the quality of the

MS at the system level. By applying external interference to the signal transmitted by the MS you can evaluate how bad the EVM can get before the signal analyzer cannot recover the signal. This allows you to verify what the minimum modulation accuracy for the MS transmitter should be in order for the BS to demodulate the signal in realistic field environments. The processing gain benefits of composite rho (or EVM) can also be useful to RF designers and system integrators for occasional bad cases of interference. For example, figure 16a shows the phase error versus time for a QPSK EVM measurement and figure 16b shows the phase error versus time for a composite rho (or EVM) measurement for a pilot-only signal with a very high LO instability. In this case, the analyzer can demodulate the signal and calculate the reference accurately. The phase error display in figure 16b will allow you to analyze the interference.



(a) **(b)**

Figure 16. cdma2000 R-Pilot signal with very high LO instability. (a) Vector diagram and phase error versus time for QPSK EVM. (b) Vector diagram and phase error versus time for composite EVM (provided with composite rho measurement).

Composite rho is useful throughout the development, performance verification, manufacturing, and installation phases of the MS life cycle as a figure of merit for the transmitter as a whole. However, we are also interested in the code-by-code composition of the composite signal. The primary means of investigating this is to look at the distribution of power in the code domain.

2.2.3 Code domain power

Code domain power is an analysis of the distribution of signal power across the set of code channels, normalized to the total signal power. To analyze the composite waveform each code channel is decoded using a code-correlation algorithm. This algorithm determines the correlation coefficient factor for each code. Once the channels are decoded, the power in each code channel is determined.

In cdma2000, the measurement is complicated by the fact that the length of the Walsh codes varies to accommodate the different data rates and spreading rates of the different radio configurations. In general, as the data rate increases the symbol period is shorter. For a specific SR, the final chip rate is constant. Therefore, fewer Walsh code chips are accommodated within the symbol period—the Walsh code length is shorter.

One effect of using variable length Walsh codes for spreading is that a shorter code precludes using all longer codes derived from it. Figure 17 illustrates this concept. If a high data rate channel using a 4-bit Walsh code such as 1, 1, -1, -1 is transmitted, all lower data rate channels using longer Walsh codes that start with 1, 1, -1, -1 have to be inactive to avoid conflicts in the correlation process at the receiver.

Walsh 4	
0	1 1 1 1
1	1 -1 1 -1
2	1 1 -1 -1
3	1 -1 -1 1

Walsh 8	
0	1 1 1 1 1 1 1 1
1	1 -1 1 -1 1 -1 1 -1
2	1 1 -1 -1 1 1 -1 -1
3	1 -1 -1 1 1 -1 -1 1
4	1 1 1 1 -1 -1 -1 -1
5	1 -1 1 -1 -1 1 -1 1
6	1 1 -1 -1 -1 -1 1 1
7	1 -1 -1 1 -1 1 1 -1

Walsh 16	
0	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1	1 -1 1 -1 1 -1 1 -1 1 -1 1 -1 1 -1 1 -1
2	1 1 -1 -1 1 1 -1 -1 1 1 -1 -1 1 1 -1 -1
3	1 -1 -1 1 1 -1 -1 1 1 -1 -1 1 1 -1 -1 1
4	1 1 1 1 -1 -1 -1 -1 1 1 1 1 -1 -1 -1 -1
5	1 -1 1 -1 -1 1 -1 1 1 -1 1 -1 -1 1 -1 1
6	1 1 -1 -1 -1 -1 1 1 1 1 -1 -1 -1 -1 1 1
7	1 -1 -1 1 -1 1 1 -1 1 -1 -1 1 -1 1 1 -1
8	1 1 1 1 1 1 1 1 -1 -1 -1 -1 -1 -1 -1 -1
9	1 -1 1 -1 1 -1 1 -1 -1 1 -1 1 -1 1 -1 1
10	1 1 -1 -1 1 1 -1 -1 -1 -1 1 1 -1 -1 1 1
11	1 -1 -1 1 1 -1 -1 1 -1 1 1 -1 -1 1 1 -1
12	1 1 1 1 -1 -1 -1 -1 -1 -1 -1 -1 1 1 1 1
13	1 -1 1 -1 -1 1 -1 1 -1 1 -1 1 1 -1 1 -1
14	1 1 -1 -1 -1 -1 1 1 -1 -1 1 1 1 1 -1 -1
15	1 -1 -1 1 -1 1 1 -1 -1 1 1 -1 1 -1 -1 1

Figure 17. Hadamard generation of Walsh codes and the effects of using variable length Walsh codes for spreading

Individual Walsh codes (or functions) are identified by W_n^N, where N is the length of the code and n is the row in the N x N Hadamard matrix. For example, $W_2$4 represents code 2 of the 4 x 4 Hadamard matrix (4-bit Walsh code).

Therefore, $W_2$4 precludes using:

- W_2^8 and W_6^8;
- W_2^{16}, W_6^{16}, W_{10}^{16}, W_{14}^{16};
- W_2^{32}, W_6^{32}, W_{10}^{32}, W_{14}^{32}, W_{18}^{32}, W_{22}^{32}, W_{26}^{32}, W_{30}^{32} (not shown in figure 17); etc.

Another way to look at the same signal is by reordering the code channels so related code channels are adjacent to each other. The so-called bit-reverse generation of Walsh channels provides us with this desired code number assignment. This is the code generation method used in W-CDMA **[4]**. The codes derived from this method are called orthogonal variable spreading factor (OVSF) codes, as opposed to Walsh codes, in W-CDMA. OVSF codes and Walsh codes are the same, only their code number assignment is different. The generation method is called "bit-reverse" because the code number in binary form is reversed (MSB is LSB, etc.) relative to the Hadamard method. For example, code channel 3 (binary: 011) in the Hadamard Walsh 8 matrix corresponds to code channel 6 (binary: 110) in the reverse-bit Walsh 8 matrix, as seen in figure 18.

Hadamard (Walsh codes)

Actual code (Walsh 8)	Code number In decimal	Code number In binary
1 1 1 1 1 1 1 1	0	000
1 0 1 0 1 0 1 0	1	001
1 1 0 0 1 1 0 0	2	010
1 0 0 1 1 0 0 1	3	011
1 1 1 1 0 0 0 0	4	100
1 0 1 0 0 1 0 1	5	101
1 1 0 0 0 0 1 1	6	110
1 0 0 1 0 1 1 0	7	111

Bit-reverse (OVSF codes)

Actual code (Walsh 8)	Code number In decimal	Code number In binary
1 1 1 1 1 1 1 1	0	000
1 0 1 0 0 0 0 0	1	001
1 1 0 0 1 1 0 0	2	010
1 0 0 0 0 0 1 1	3	011
1 0 1 0 0 0 0 0	4	100
1 0 1 0 0 1 0 1	5	101
1 0 0 1 1 0 0 1	6	110
1 0 0 1 0 1 1 0	7	111

Figure 18. Hadamard versus bit-reverse

For the reverse link, as seen earlier, the physical channels are I/Q multiplexed. HPSK is applied to limit the peak-to-average power ratio. However, HPSK limits the choice of Walsh codes. In order to benefit from this function, only even-numbered Walsh codes, which consist of pairs of identical consecutive chips, can be used. For example, W_2^4 = (1,1,-1,-1) would meet this condition, but W_1^4 = (1,-1,1,-1) would not **[3]**.

To maximize the benefits of HPSK, the Walsh codes for the different channels are defined as follows:

- The R-Pilot is always spread by code W_0^{32} = (1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1).
- The R-FCH is always spread by code W_4^{16} = (1,1,1,1,-1,-1,-1,-1,1,1,1,1,-1-1,-1,-1).
- The R-DCCH is always spread by code $W_8{}16$ = (1,1,1,1,1,1,1,1,-1,-1,-1,-1,-1,-1,-1,-1).
- When only one R-SCH is to be transmitted, R-SCH1 is spread by code $W_2{}4$ = (1,1,-1,-1). Only for the highest data rates should W_1^2 = (1,-1) be used. This Walsh code defeats the benefits of HPSK, so it should be avoided.
- When two R-SCHs are used, the recommended configuration is to have SCH1 using $W_2{}4$ = (1,1,-1,-1) and SCH2 using $W_6{}8$ = (1,1,-1,-1,-1,-1,1,1). These two codes are not orthogonal to each other. This is not a problem because, as seen in figure 4, the two channels are I/Q multiplexed (one is transmitted in I and the other one in Q). This makes them orthogonal regardless of the spreading code used. For high data rate cases, both SCHs can use shorter codes.

Figure 19 shows how the selected codes for the different channels map onto the bit-reverse code tree. The dark grey codes are the selected codes. The light grey codes are non-orthogonal to the selected codes.

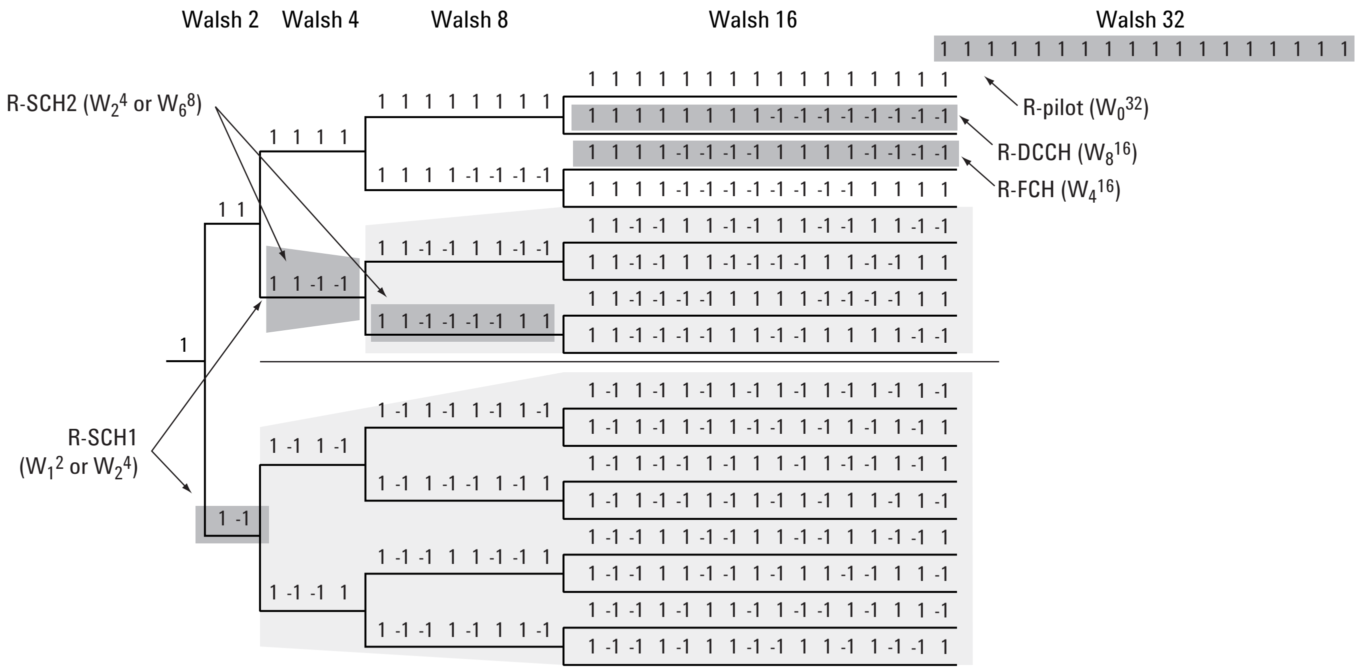


Figure 19. Mapping of reverse link Walsh codes onto the bit-reverse Walsh code tree

For the worst cases (highest data rates), the HPSK requirements will not be fulfilled. It is expected that this will only occur for a very small percentage of cases.

Defining the Walsh codes avoids code-usage conflicts. By limiting the choice of code channel configurations, the power statistics (CCDF) for the signals are also better determined.

In terms of code capacity, channels with higher data rates (shorter code lengths) occupy more code space. For example, W_1^2 occupies twice as much code space as W_2^4, and four times more code space than W_4^{16}. In the code domain power display, wider bars represent shorter code (higher data rate) channels. Figure 20 shows the code domain power display, in bit-reverse mode, for a signal with a R-Pilot, a R-FCH, and a R-SCH1. The R-SCH1 (W_2^4) is much wider than the Walsh 16 channels (W_0^{16} and W_4^{16}).

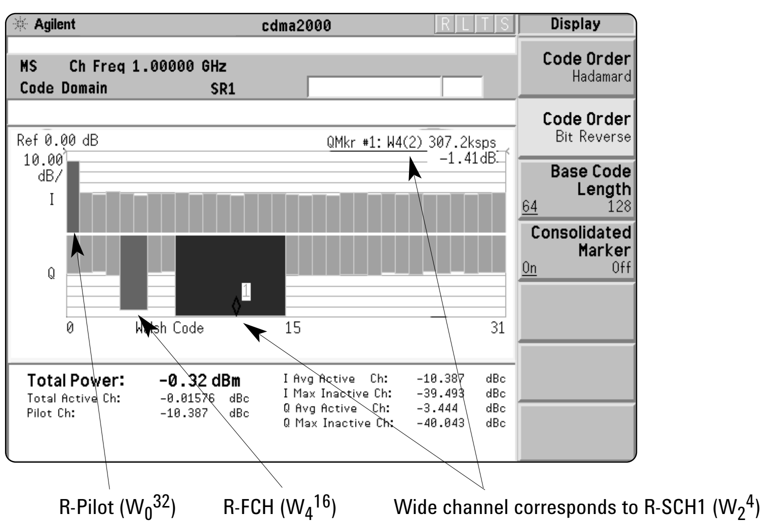


Figure 20. Code domain power for a signal with a R-Pilot, a R-FCH, and a R-SCH1 (W_2^4)

The code domain power measurement not only helps you verify that each Walsh channel is operating at its proper level, but also identify problems throughout the transmitter design, from the coding to the RF section. In particular, the level of the inactive channels can provide useful information about specific impairments **[6]**. The projection of the error signal over the code domain, known as code domain error, is of even more interest. You want the error power to be distributed through the code domain, rather than concentrated in a few codes, to avoid code-dependent channel quality variations. However, many transmitter impairments, such as amplifier compression and LO instability, cause uneven distribution of the error throughout the code domain. In these cases, energy is lost from the active channels and appears in related code channels in deterministic ways **[1]**. For this reason, it is useful to ensure that the code domain error is under a certain limit. The peak code domain error measurement (shown in figure 16b in combination with a composite rho measurement) indicates the maximum code domain error in the signal and to which code channel this error belongs. In cases of transmitter impairments, the peak code domain error typically belongs to one of the active channels.

Related to code domain power, IS-95 standards specify a pilot channel to code channel time tolerance and pilot channel to code channel phase tolerance for the BS **[1]**. Since the cdma2000 MS has many similarities with a BS, these tests will probably be part of the IS-2000 standard for MS. However, they are irrelevant if digital summing is used, since digital summing prevents delays and phase shifts between channels.

Apart from looking at the code domain power, it is useful to analyze a specific code channel. The following sections describe some analysis tools and how they can be applied. Figure 21 shows how the references for these measurements are calculated.

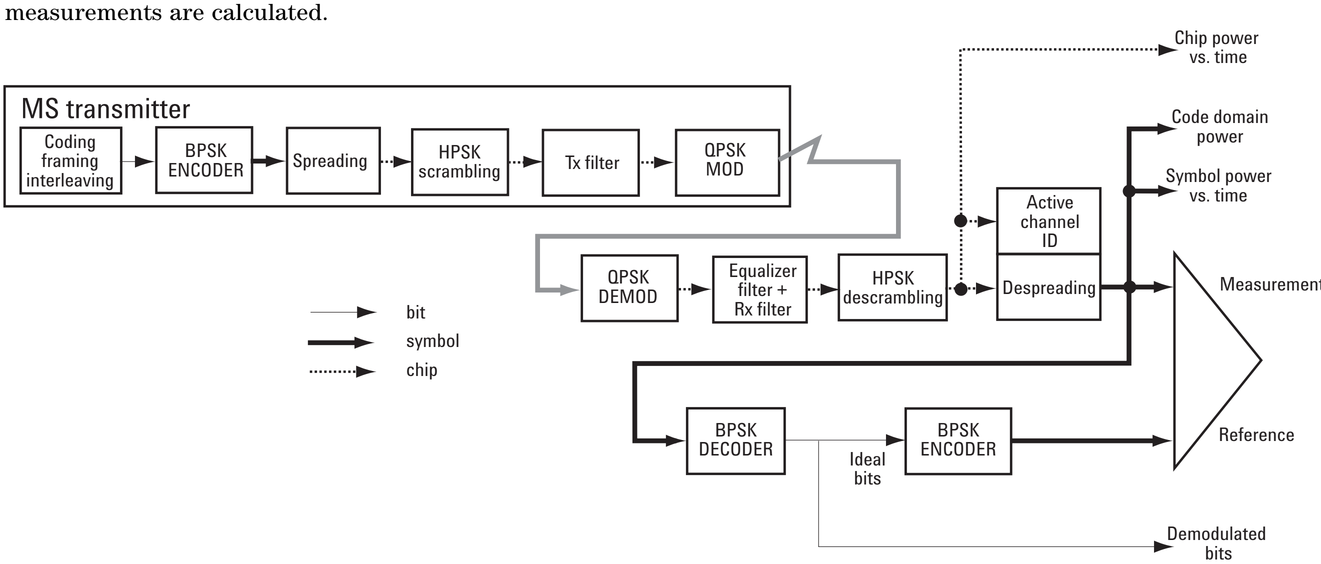


Figure 21. Process to calculate code domain power, symbol EVM, symbol power and chip power versus time, and the demodulated bits for a cdma2000 reverse link signal

2.2.4 Symbol EVM

By descrambling and despreading the signal, you can analyze the constellation for a specific code channel at the symbol level, even in the presence of multiple code channels. The measured signal is complex descrambled, despread, and BPSK decoded to bits. The ideal bits are then BPSK encoded to obtain the reference at the symbol level. This reference is then compared to the measured, despread symbols (figure 21).

An RF impairment that affects symbol EVM will also affect the composite EVM. For example, an amplifier compression problem will appear both in the composite EVM and in the symbol EVM measurement. However, because of the processing gain, symbol EVM will mute the impairment. So why use symbol EVM?

Symbol EVM provides the bridge between RF and the demodulated bits. Since it includes the processing gain, it provides baseband engineers a measure of modulation quality closer to real-life performance. In this sense, you can think of it as the actual quality the user will experience in that channel (similar to the reciprocal of BER).

The relationship between symbol EVM and chip EVM depends on the Walsh code length. For short Walsh code channels (less processing gain) chip modulation errors have a significant effect on symbol EVM. But for long code channels (more processing gain), chip modulation errors have little effect on symbol EVM. Therefore, there is a compromise between the data rate and the modulation quality. In this sense, symbol EVM is particularly useful to baseband DSP engineers to analyze how different impairments affect the quality of channels at different data rates. For example, figure 22 shows the cdma2000 code domain power measurement (bit reverse display) for a signal with a R-Pilot, a R-FCH, and a R-SCH1 (W_1^2). The signal suffers from LO interference. Figure 22a shows the constellation and symbol EVM (around 19 percent) for the R-FCH (W_4^{16}) channel. Figure 22b shows that the higher data rate channel, R-SCH1 (W_1^2), suffers from a higher symbol EVM (around 28 percent).

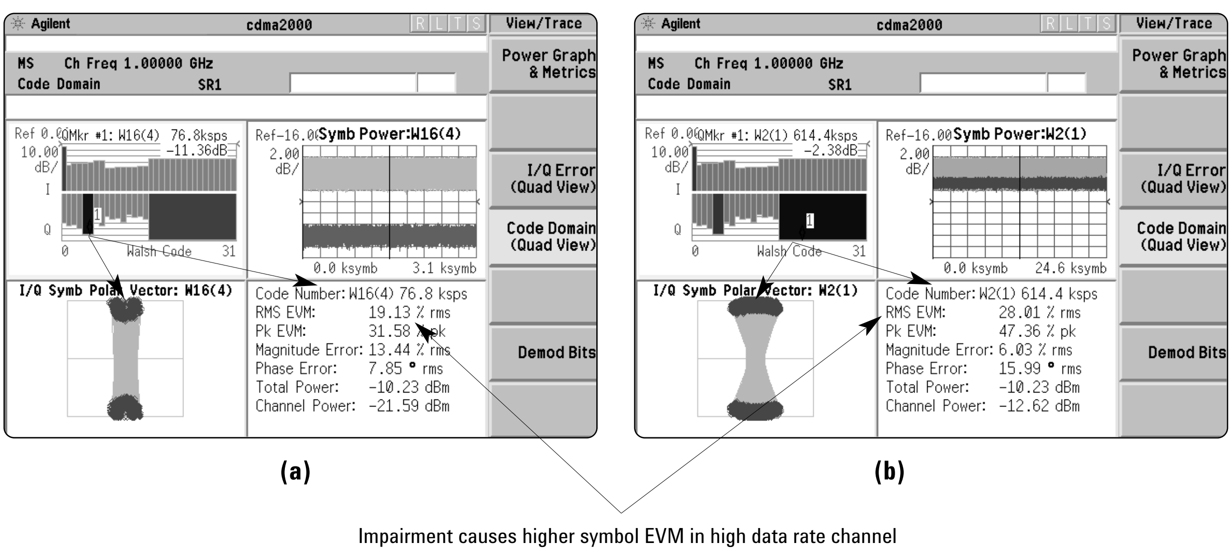
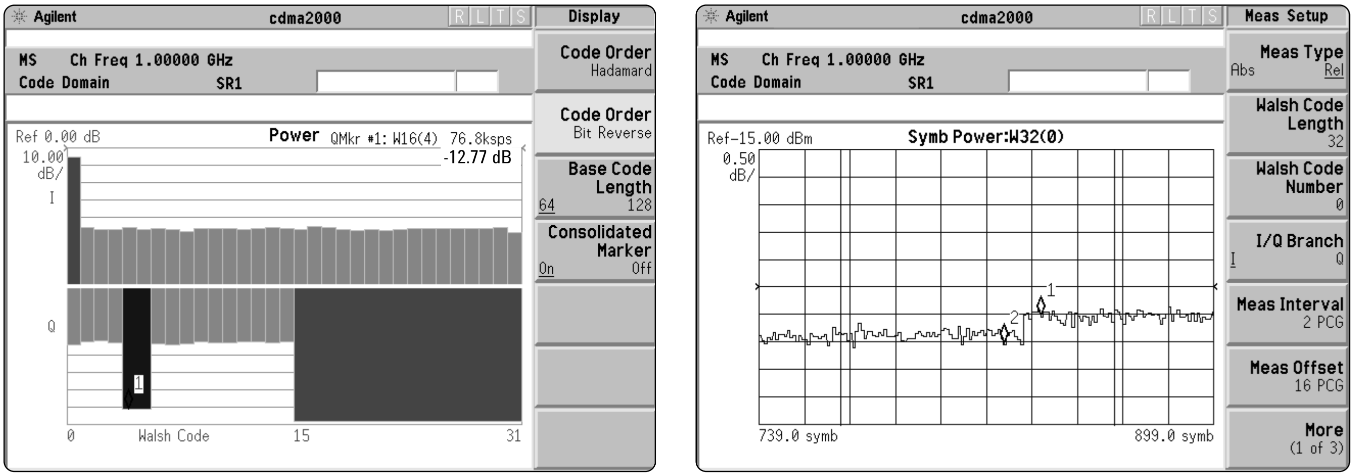


Figure 22. cdma2000 code domain power measurement (bit reverse display) for a signal with a R-Pilot, a R-FCH (at –12.77 dB), and a R-SCH1 (W12 at –3.77 dB). Signal has a LO interference problem. (a) Symbol EVM measurement for the R-FCH. (b) Symbol EVM measurement for the R-SCH1.

2.2.5 Symbol power versus time

Analyzing the power for a specific code channel versus time (or versus symbol) can be particularly useful to monitor the power and response of the MS power control system for different channels. For example, figure 23 shows a symbol power increase of .5 dB in the R-FCH, for the same signal used for figure 22, but with no impairments.



(a) **(b)**

Figure 23. (a) cdma2000 code domain power measurement (bit reverse display) for a signal with a R-Pilot, a R-FCH (at –12.77 dB), and a R-SCH1 (W12 at –3.77 dB). (b) Symbol power versus time for the R-FCH.

Figure 24 shows the symbol power versus time in combination with the chip power for the signal versus time. This is particularly useful for system integrators to analyze the power amplifier response (ripple) to a series of power control commands.

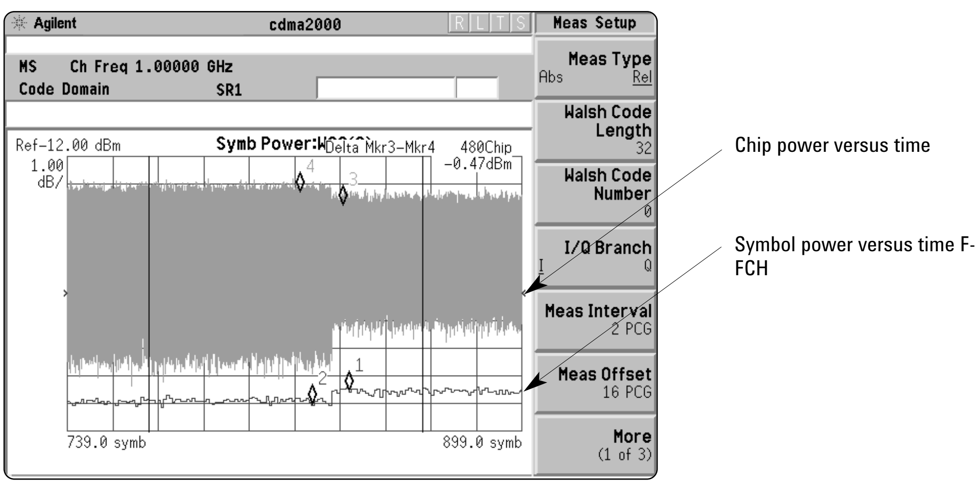


Figure 24. Chip power versus time for a signal with a R-Pilot, a R-FCH (at –12.77 dB) and a R-SCH1 (W12 at –3.77 dB), combined with symbol power versus time for the R-FCH

2.2.6 Demodulated bits

By obtaining the demodulated symbols after descrambling and despreading for each code channel, the correct symbol patterns can be verified. This is particularly important for the power control bits, since power control is absolutely critical to system performance. In cdma2000, the MS uses the R-Pilot to send power control bits to the BS. The power control bits are multiplexed with the pilot data bits. Figure 25 shows the demodulated bits for the R-Pilot of a cdma2000 signal with the same channel configuration as in previous figures.

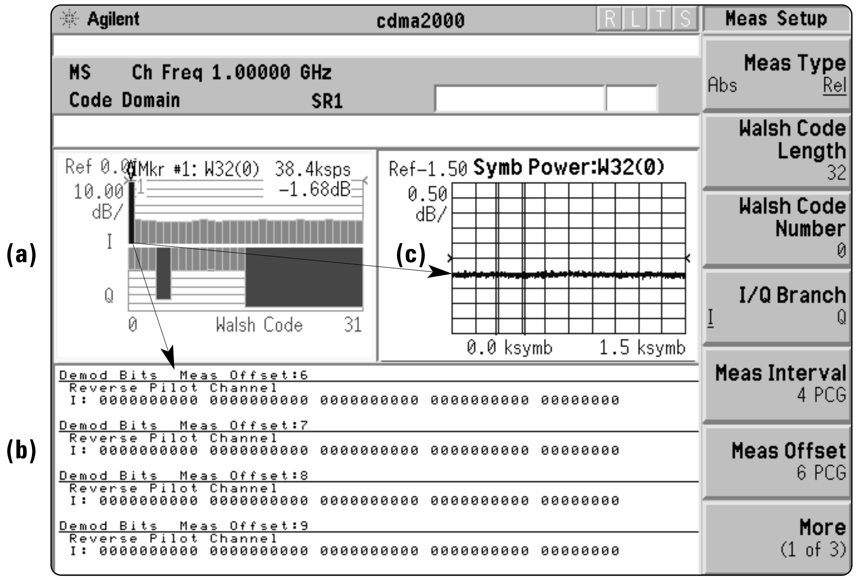


Figure 25. (a) cdma2000 code domain power measurement (bit-reverse display) for a signal with R-Pilot, a R-FCH (at –12.77 dB), and a R-SCH1 (W_1^2 at –3.77 dB). (b) Demodulated bits for the R-Pilot. (c) Symbol power versus time for the R-Pilot.

Demodulated bits is an important troubleshooting tool for baseband engineers to identify coding, interleaving, and power control bit errors. In many cases it can help you clarify situations where the BS and MS are having problems communicating with each other. Analyzing the demodulated bits may confirm whether the error is coming from the MS coding and interleaving or the BS de-interleaving and decoding process.

2.3 Measuring receiver performance

Since the air interface for the cdma2000 forward link is similar to cdmaOne, the same issues and measurements for cdmaOne mobile receiver test apply to cdma2000. However, in cdma2000 the testing is complicated by a couple of factors that are fundamental for a 3G system: capability for variable data rates and higher capacity. The following sections describe how this impacts the mobile receiver test and what new source requirements may be needed to perform appropriate testing.

2.3.1 Performance tests at variable data rates

As seen earlier, cdma2000 uses different RCs and Walsh code lengths to accommodate the variable data rates. In order to demodulate a channel the MS receiver must identify the channel's data rate. The IS-2000 standard requires demodulation performance tests be made for a large number of channels at different RCs and data rates to ensure good receiver performance. This poses a challenge both in the time spent and source requirements for the test.

To perform these tests you need a source capable of simulating fully-coded forward link signals with channels at all possible RCs and data rates. You must be able to change parameters and input data. The best solution for this is to use a real-time cdma2000 generator, with which you can change the channel configuration and parameters to generate a new signal in a few seconds. (See appendix for information on available cdma2000 real-time generators.)

2.3.2 Quasi-orthogonal functions

High data rate channels occupy a lot of the BS code space. There may be situations where a few users (or even a single user) transmitting data at high data rates use all the available codes. To obtain more code space, the IS-2000 standard specifies a new set of orthogonal codes to complement the existing Walsh codes. The new codes are known as quasi-orthogonal functions (QOF). The two sets of codes (Walsh and QOF) are not orthogonal to each other, but codes within the set preserve orthogonality. Therefore, the QOFs increase the code space at the expense of higher interference.

The receiver must be able to demodulate Walsh channels in the presence of QOF channel interference. Therefore, the receiver tester source must be able to generate cdma2000 channels spread with QOF codes.

Appendix: Agilent solutions for cdma2000 MS design and test

This section provides a list of Agilent's solutions that can help you develop and test your cdma2000 MS design.

Design software and simulation

You can use the Agilent Advanced Design System (ADS) for cdma2000 systems, circuits, and DSP designs. ADS is a versatile design tool that includes a wide array of RF, analog, and DSP models and simulation capability all accessible in a single environment.

The cdma2000 compliant design library (E8877A/AN) is a collection of models for the physical layer of cdma2000. The library includes the following models and application examples:

- rake receivers for both the forward link and the reverse link
- forward link transmissions with SR1 and SR3
- reverse link transmissions with SR1 and SR3
- reverse link with HPSK modulation (SR1 and SR3)
- channel encoding with turbo codes with BER/FER measurement
- measurement of ACPR, CCDF and EVM
- a variety of RCs
- transmission power control for both forward and reverse links
- complete RF transmitter and receiver design capability, including nonlinear components, phase noise, and intermodulation distortion
- signal source Design Guide for convenient configuration of cdma2000 sources

The library includes advanced features such as HPSK spreading (reverse link), pilot aided coherent demodulation (reverse link), channel coding including turbo codes, mapping and de-mapping scheme for rate matching, and orthogonal transmit diversity (OTD).

Signal generation

The Agilent ESG-D/DP series RF signal generator with Option 101 is capable of simulating statistically correct forward and reverse link cdma2000 signals for MS component and subsystem testing. An easy-to-use interface allows you to

- select the spreading rate (SR1 or SR3)
- select from several predefined cdma2000 multi-channel signals
- use the table editor to fully configure a cdma2000 multi-channel signal per your requirements

The Agilent ESG-D/DP series RF signal generator with Option 201 is capable of simulating fully coded cdma2000 signals (SR1) for MS receiver test. You can conduct frame or bit error tests and functional tests of the mobile unit's protocol handling. It is backward compatible with cdmaOne systems using RC 1 or 2. The key features are

- Fully coded channels including pilot, sync, paging, quick paging, fundamental and supplemental traffic channels that supports QOF and OCNS. Channels are highly configurable using the built in table editor, with control over power level, ISI filter type, PN offset, even second delay, and others, depending upon channel type.
- Paging: Insert single messages into the built-in periodic paging stream (PPS) asynchronously.
- F-FCH: Select the radio configuration (1 to 5), data rate (full, half, one-quarter, or one-eighth), Walsh code, long-code mask, data source (this can be PN9, PN15, any 4-bit pattern, or a user file), frame offsets 0 to 15, and power control bit handling. Power control bit handling allows a ramp of 1 to 80 up or down for closed loop power control, plus all up or all down. Supports QOFs 0 to 3.

Power meters and sensors

The Agilent EPM series power meters and E-series E9300 power sensors provide average power measurements on RF and microwave signals, regardless of the modulation or complexity, over a wide 80-dB dynamic range. The E9300 power sensors are bandwidth independent so you don't have to worry about matching sensor bandwidth to the modulation format of your signal under test. High power measurements up to 25 W (+44 dBm) are available in the E9300 family.

Recommended power meters and sensors for cdma2000 average power measurements are

- E4418B power meter, single channel
- E4419B power meter, dual channel
- E9301A power sensor, 10 MHz to 6 GHz, -60 to +20 dBm
- E9301H power sensor, 10 MHz to 6 GHz, -50 to +30 dBm
- E9300B power sensor, 10 MHz to 6 GHz, -30 to +44 dBm

Other power sensors in the 8480 series are compatible with the E4418B/9B power meters.

Power supplies

Agilent 66319B/D, 66321B/D single and dual dc output high performance power supplies combined with the 14565A Device Characterization Software provide very fast transient output response with a built-in advanced "DSP" based measurement system. They are designed for testing digital wireless appliances with the following functions:

- replace the main battery and power adapter
- emulate internal battery resistance
- very fast output response emulates battery voltage response
- very low voltage drop in response to pulsed current demands
- accurately measure battery current drains (dc average, leakage, stand by mode and talk mode)
- dual dc output models for testing and calibrating charger circuitry (source/sink capability)
- Graphical User Interface software for easy power supply control and measurement setup (no programming required)

Signal analysis

This table provides the list of Agilent signal analyzers and their cdma2000 measurement capabilities for MS transmitter test (as of 8/2000).

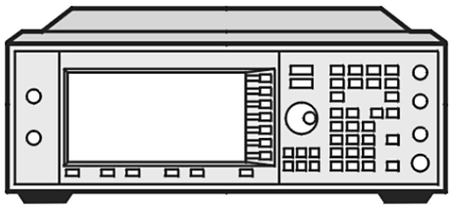
Table 1. Agilent signal analysis capabilities for cdma2000

cdma2000		**Agilent signal analyzers**				
		Vector signal analyzers		Spectrum analyzers		
Measurements		E4406A VSA transmitter tester[1]	89400A series vector signal analyzer[2]	89600 vector signal analyzer[2]	8560-E series spectrum analyzer[3]	ESA-E series spectrum analyzer[2]
Channel power		●	●	●	●	●
Occupied bandwidth		●			●	●
In-band emissions	ACPR	●	●[5]		●[4]	●
	In-band spurious	●	●[5]		●	●
Out-of-band emissions (spurious/harmonics)		up to 4 GHz[5]	up to 2.6 GHz[5]		●	●
Peak/average power ratio		●	●	●		
CCDF		●	●	●		
Modulation quality	Rho	●	●[6, 7]	●[6]		
	QPSK EVM	●	●	●		
	Composite EVM	●				
	I/Q offset	●	●			
	Frequency accuracy	●	●			
	Code domain power	●				
	Symbol EVM	●				
	Symbol power vs. time	●				
	Composite chip power vs. time	●				
	Demodulated bits	●				

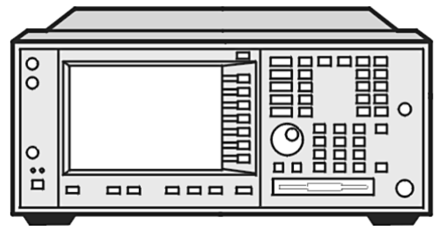
Notes:
1. Measurement preconfigured for IS-2000 standard.
2. Some measurements pre-configured for IS-95. Measurement parameters can be manually changed to accommodate cdma2000 SR1.
3. Measurements are not pre-configured to a specific standard. Measurement parameters can be manually selected to accommodate IS-2000 standard.
4. Measurement can be performed if same integration bandwidth is used for main channel and offsets. Power (or rms) averaging is not available.
5. Manual measurement (no automatic spurious search or ACPR measurement).
6. There are several interpretations of rho. The 89400 series and 89600 vector signal analyzers can make the rho measurement with certain assumptions.
7. IS-95 measurement. cdma2000 measurement can be made with certain limitations.

Instruments used for measurement examples

The measurement examples and screen images in this application note were obtained using the following instruments:



Agilent ESG-D Series RF digital signal generator Option 101



Agilent E4406A VSA transmitter tester

Acronym glossary

2G . . . . .Second Generation
3G . . . . .Third Generation
3GPP2 . . . . .Third-Generation Partnership Project 2
ACLR . . . . .Adjacent Channel Leakage Power Ratio
ACP . . . . .Adjacent Channel Power
ACPR . . . . .Adjacent Channel Power Ratio
ARIB . . . . .Japanese Association of Radio Industries and Businesses
BPSK . . . . .Binary Phase Shift Keying
BS . . . . .Base Transceiver Station
CCDF . . . . .Complementary Cumulative Distribution Function
CDMA . . . . .Code Domain Multiple Access
cdmaOne . . . . .Name identifying the EIA/TIA standard (commonly referred to as IS-95) for 2G
cdma2000 . . . . .Name identifying the EIA/TIA standard (IS-2000) for 3G
CRC . . . . .Cyclic Redundancy Check
DS . . . . .Direct Spectrum
DSP . . . . .Digital Signal Processing
EVM . . . . .Error Vector Magnitude
F-DCCH . . . . .Forward Dedicated Control CHannel
F-FCH . . . . .Forward Fundamental Channel
FIR . . . . .Finite Impulse Response
F-Paging . . . . .Forward Paging
F-Pilot . . . . .Forward Pilot
F-SCH . . . . .Forward Supplemental Channel
F-Sync . . . . .Forward Sync
F-Traffic . . . . .Forward Traffic
GMSK . . . . .Gaussian Minimum Shift Keying
GPS . . . . .Global Positioning System
HPSK . . . . .Hybrid Phase Shift Keying
IF . . . . .Intermediate Frequency
IMT-2000 . . . . .International Mobile Telecommunications-2000
I/Q . . . . .In-phase/Quadrature
IS-2000 . . . . .EIA/TIA interim standard 2000 (see cdma2000)
IS-95 . . . . .Interim Standard for US Code Division Multiple Access
LO . . . . .Local Oscillator
LSB . . . . .Least Significant Bit
MC . . . . .Multiple Carrier
MS . . . . .Mobile Station
MSB . . . . .Most Significant Bit
OCQPSK . . . . .Orthogonal Complex Quadrature Phase Shift Keying
OQPSK . . . . .Offset Quadrature Phase Shift Keying
PSK . . . . .Phase Shift Keying
QAM . . . . .Quadrature Amplitude Modulation
QOF . . . . .Quasi-Orthogonal Functions
QPSK . . . . .Quadrature Phase Shift Keying
R&D . . . . .Research and Development
RC . . . . .Radio Configuration
RF . . . . .Radio Frequency
R-CCCH . . . . .Reverse Common Control Channel
R-DCCHR-EACH .Reverse Enhanced Access Channel
R-FCH . . . . .Reverse Fundamental Channel
RMS . . . . .Root Mean Square
R-Pilot . . . . .Reverse Pilot
R-SCH . . . . .Reverse Supplemental Channel
SR . . . . .Spreading Rate
TIA . . . . .Telecommunications Industries Association
TTA . . . . .Korean Telecommunications Technology Association
TTC . . . . .Telecommunication Technology Committee
W-CDMA . . . . .Wideband-Code Division Multiple Access (3G system)
UE . . . . .User Equipment

For more information regarding these acronyms and other wireless industry terms, please consult our wireless dictionary at ***www.agilent.com/find/wireless****.*

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