Agilent
Performing cdma2000 Measurements Today

Application Note 1325

Agilent Technologies
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Introduction

cdma2000 is one of the proposals for the IMT-2000 requirements for a 3G global wireless communications system. The 3GPP2 is implementing this wideband CDMA system as a derivative of the IS-95-B CDMA system, also known as cdmaOne. The 3GPP2 organizational partners are ARIB, TTC, TIA, and TTA.[1]

The cdma2000 specifications are still being defined. However, R&D engineers are already developing cdma2000 systems and need to test their designs today.

This application note describes measurements to test and troubleshoot your cdma2000 RF designs. It also provides a list of HP solutions for these measurements. Agilent Technologies is committed to providing you with design tools and test equipment that will keep pace with all of the evolving 3G standards.

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

Understanding CDMA Measurements for Base Stations and Their Components ***[1]***.

Note: The above application note can be downloaded from the Web at the following URL and printed locally:

http://www.tm.agilent.com/tmo/Notes/English/5968-5858E.html

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1. See Glossary for the meanings of these acronyms.

1. Basic concepts of cdma2000

The main advantages that cdma2000 offers over other IMT-2000 proposals are its backwards compatibility with cdmaOne systems and its smooth migration from 2G (Second Generation) cdmaOne systems to 3G. Figure 1 shows the expected evolution from cdmaOne to cdma2000 systems.

Spreading Rate

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

1. **SR1.** A Spreading Rate 1 signal has a chip rate of 1.2288 Mcps and occupies the same bandwidth as cdmaOne. 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 QPSK (Quadrature Phase Shift Keying) modulation rather than dual BPSK (Binary Phase Shift Keying) in the forward link.
   - Pilot signal to allow coherent demodulation, and HPSK (Hybrid Phase Shift Keying) spreading in the reverse link.

2. **SR3.** A Spreading Rate 3 signal has a rate of 3.6864 Mcps (3 ¥ 1.2288 Mcps) and occupies three times the bandwidth of cdmaOne. The SR3 system incorporates all of the new coding implemented in an SR1 system and supports higher data rates. It has two air interface options:

   - Direct Spread (DS): uses a single 3.75-MHz-wide carrier. It requires clear spectrum (green field) to operate.
   - Multi-Carrier (MC): uses three 1.25-MHz-wide carriers. It is designed to allow SR3 signals to be directly overlaid on top of existing cdmaOne systems. To achieve an overlay system, the SR3 MC mode breaks up the data into three carriers, each of which is spread at 1.2288 Mcps (see Figure 2).

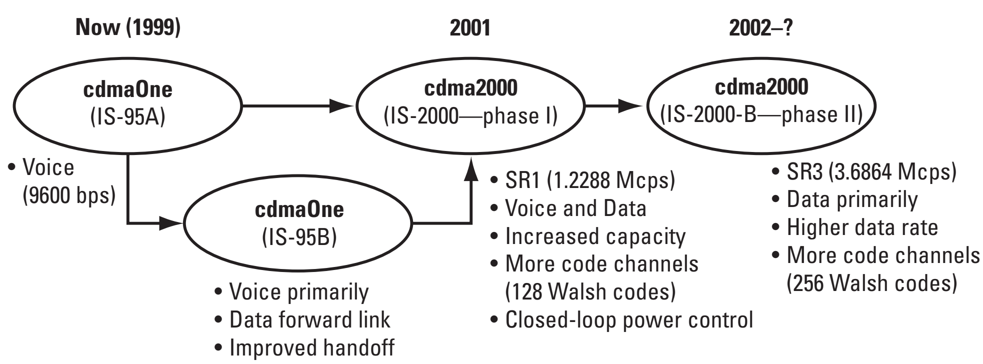


Figure 1. Evolution from cdmaOne to cdma2000

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 for voice supports 4.8, 2.7, and 1.5 kbps, while also supporting data at 19.2, 38.4, 76.8, and 153.6 kbps. It operates at SR1.

Each base station or mobile station can transmit several channels using different Radio Configurations at the same Spreading Rate. Refer to **[2]** for detailed information on the different RCs.

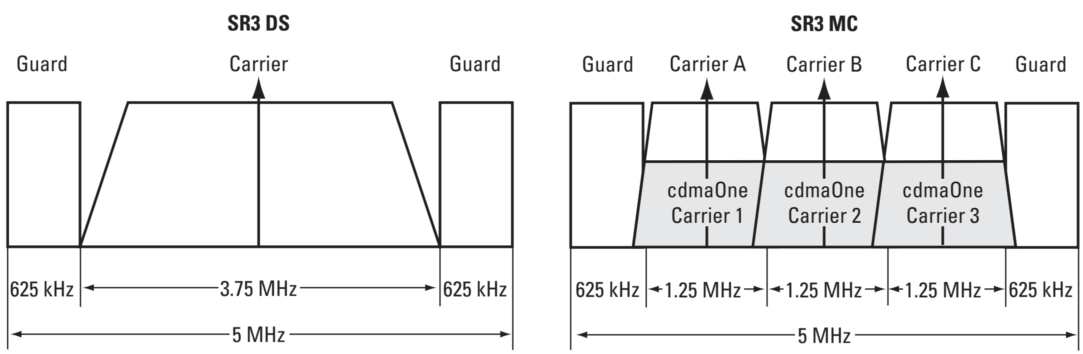


Figure 2. Bandwidth limits for SR3DS and SR3 MC

2. Measurements

Although the exact cdma2000 measurement specifications have not been defined, in general we can assume that the basic measurement methodology will be similar to cdmaOne. Therefore, in this chapter cdmaOne measurements are used as a reference. For information on cdmaOne measurements refer to *Understanding CDMA Measurements for Base Stations and Their Components* **[1]**.

With cdmaOne measurements as the basis, this chapter describes the measurements that you can make on your cdma2000 components and systems today. Specific test parameters and special considerations for the particular measurements are provided. Refer to Appendix B for a list of HP instruments recommended for these measurements.

Signal simulation for component testing

In component testing, the stimulus signal must provide the appropriate channel configuration (number of channels and individual channel settings—data rate, power level, and so forth—for each channel). It must also provide the correct modulation, filtering and chip rate for the system. This is important when performing modulation quality and RF power measurements.

Correct simulation of any CDMA signal for power measurements requires that the stimulus be not only spectrally correct but also statistically correct. That is, the signal must provide the correct peak-to-average power ratio statistics in addition to adequate spectral shape. That is particularly important when testing Adjacent Channel Power Ratio (ACPR). The power statistics of a CDMA signal depend mainly on its channel configuration, modulation, filtering and clipping level. Therefore, it is important that you test your components with signals that have the same channel configuration and parameters as real-world signals (see section below on RF power measurements).

CdmaOne uses dual BPSK for the forward link and OQPSK (Offset Quadrature Phase Shift Keying) for the reverse link. cdma2000 uses QPSK modulation for the forward link and QPSK modulation with HPSK spreading for the reverse link. Both forward and reverse links may haveseveral channels, and individual characteristics (RC, power level, and so forth) for each channel. The chip rate depends on the mode selected (SR1 or SR3).

RF power measurements

RF power measurements include channel power, occupied bandwidth, peak-to-average power ratio, Complementary Cumulative Distribution Function (CCDF) curves, ACPR, in-band spurious and out-of-band spurious/harmonics. Although the actual test methodology has not yet been specified, you can make power measurements of your cdma2000 system components or transmitters today using the cdmaOne measurement specifications as a general guideline. (Refer to **[1]** for a detailed description of cdmaOne measurements). Some measurement parameters may be different from cdmaOne, depending on the SR mode. For example, when performing channel power measurements on SR3 signals, an integration bandwidth of 3.75MHz is appropriate. In the case of ACPR and in-band spurious, the appropriate offsets can be easily calculated, as shown in the following section.

The following sections focus on three RF power measurements that are often related to each other: ACPR, peak-to-average power ratio and CCDF curves.

ACPR

The Adjacent Channel Power Ratio 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 NEMs (Network Equipment Manufacturers) typically specify ACPR as a figure of merit for component testing [1]. This may also apply to cdma2000.

As mentioned earlier, the appropriate measurement parameters depend on the Spreading Rate. You can use cdmaOne parameters for SR1, since they both use the same chip rate and filtering. For SR3, an integration bandwidth of 3.6864 MHz is appropriate. You can easily calculate appropriate frequency offsets for realistic cdma2000 SR3 ACPR[1] measurements in the following way:

- For multiple-carrier (SR3 MC) configurations, add the frequency spacing between carriers (1.25 MHz) to the original cdmaOne offset.For example, an offset of 885 kHz in cdmaOne is equivalent to an offset of 2.135 (0.885+1.25) MHz in cdma2000 SR3 MC. Figure 3 shows an example of an ACPR measurement for a cdma2000 SR3 MC signal.

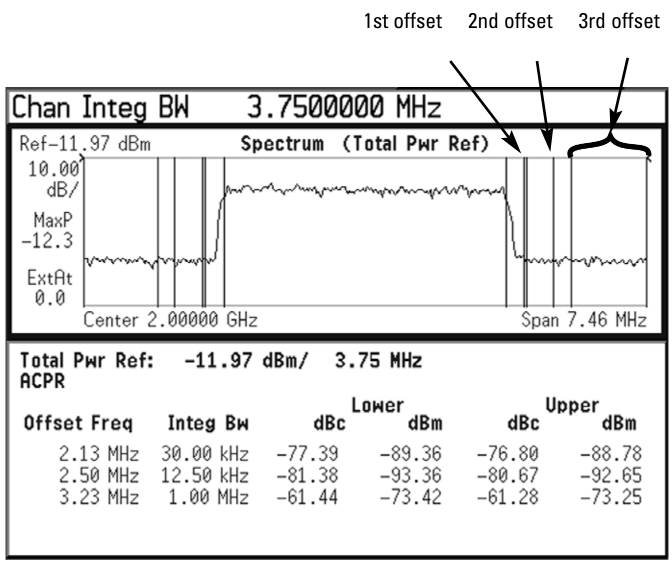


Figure 3. ACPR measurement for a cdma2000 SR3 MC signal

- The limits of the baseband filter frequency response for SR3 DS in the original cdma2000 proposed specifications are wider than for SR1 (or cdmaOne). Figure 4 shows the original proposed specifications for the cdma2000 baseband filters, where the limits for the SR3 DS filter are three times wider than the ones for the SR1 (or cdmaOne) filter. In this case, you can easily calculate the appropriate SR3 DS offsets by multiplying the cdmaOne offset frequencies by three.

For example, an offset of 885 kHz in cdmaOne would be equivalent to an offset of 2.655 (3 ¥ 0.885) MHz in cdma2000 SR3 DS. Figure 5 shows an example of the measurement for a cdma2000 SR3 DS signal. These calculations may be different for newer proposals or final specifications for this evolving standard.

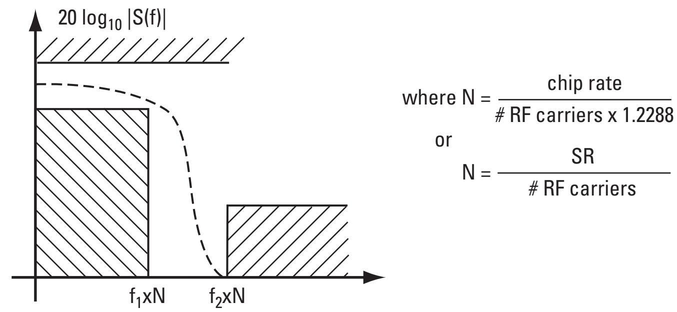


Figure 4. Proposed limits for cdma2000 baseband filters

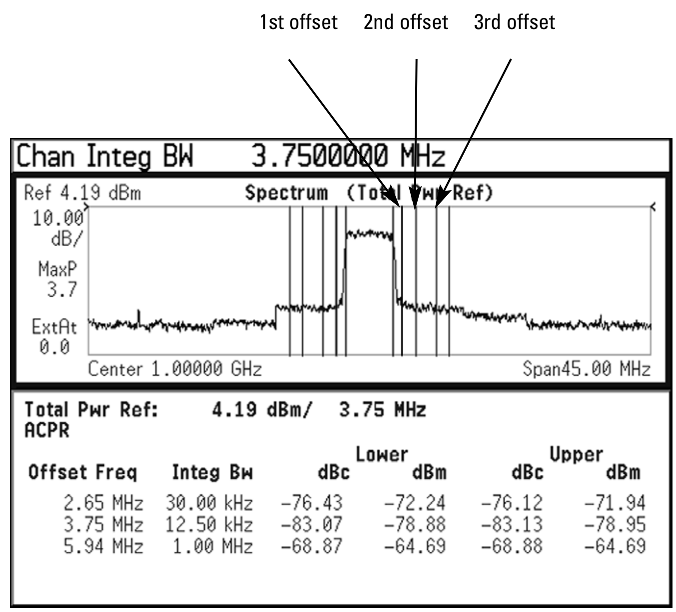


Figure 5. ACPR measurement for a cdma2000 SR3 DS signal

When designing components and testing ACPR, it is important to take into account the power statistics of the signal. The statistics of the signal determine the headroom required in amplifiers and other devices. Different peak-to-average ratio values have a different impact on nonlinear components. A signal with a higher peak-to-average power ratio may cause more interference in the adjacent channel. Therefore, ACPR measurements can provide different results depending on the statistics of the signal. In CDMA systems, the statistics of the signal depend on its channel configuration. The safest approach is to select at least one high-stress stimulus signal, and test with various combinations of channels. You can use CCDF curves for this task.

1.The same calculations may apply to the in-band spurious measurement

Peak-to-average power ratio and CCDF curves

Peak-to-average power ratio is the ratio of the peak envelope power to the average envelope power of a signal during a given period of time.

A CCDF curve goes a step beyond and fully characterizes the power statistics of the signal [4]. It provides the distribution of particular peak-to-average ratios versus probability. Figure 6 shows the CCDF curves for two cdma2000 SR3 DS signals with different channel configurations. For a probability of 0.01%, the signal with 24 code channels has a higher peak-to-average ratio (10.92 dB) than the signal with 9 code channels (8.54 dB).

CCDF curves can help you:

- Determine the headroom required when designing a component.
- Confirm that the component design is adequate. For example, you can compare the CCDF curves of a signal at the input and output of the RF amplifier. If the design is correct, the curves coincide. If the amplifier compresses the signal, the peak-to-average ratio of the signal is lower at the output of the amplifier.
- Troubleshoot a system or subsystem design. You can make CCDF measurements at several points in the system design. For instance, if the ACPR of a transmitter is too high, you can make CCDF measurements at the input and output of the amplifier to determine if the amplifier is compressing the signal.

The measurement methodology for peak-to-average power ratio and CCDF curves is the same regardless of the signal's format.

Modulation quality measurements—forward link

Both Error Vector Magnitude **(EVM)** and **rho** provide a measure of the transmitter's modulation quality. Additionally, you can analyze the individual code channels of the signal using the **code-domain power** measurement.

Error vector magnitude (uncoded)

EVM is a common modulation quality metric widely used in digital communications systems. EVM is not part of the cdmaOne specifications. Traditional algorithms (uncoded EVM) synchronize to the chip stream, but do not de-spread and decode the symbols forCDMA signals. The reference signal is computed from the received chips. Therefore, uncoded EVM does not detect coding errors. However, it can be used as an indicator of modulation quality and as a troubleshooting tool. Uncoded EVM is sensitive to any impairments that occur at the baseband filters, I/Q modulator, IF and RF sections of the transmitter (see **[3]** for more information on EVM).

You can use existing instrumentation to perform uncoded EVM measurements on a cdma2000 pilot signal or on a signal with multiple code channels, provided that it maps onto a known constellation.[1] For example:

- As with cdmaOne, a cdma2000 pilot signal maps onto a **QPSK** constellation (see Figure 7). For SR1 and SR3 MC, the test setup (filtering and chip rate) is identical to cdmaOne. In the case of SR3 DS, the chip rate (symbol rate parameter in some instruments) is different (3.6864 Mcps).

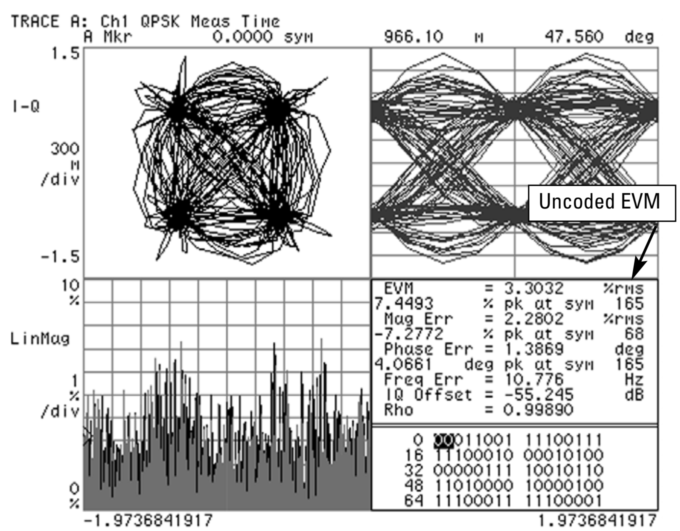


Figure 7. Uncoded EVM measurement on a cdma2000 SR1 pilot signal (forward link)

1. Correct filtering at the test instrument is required (cdmaOne filtering parameters can be used).

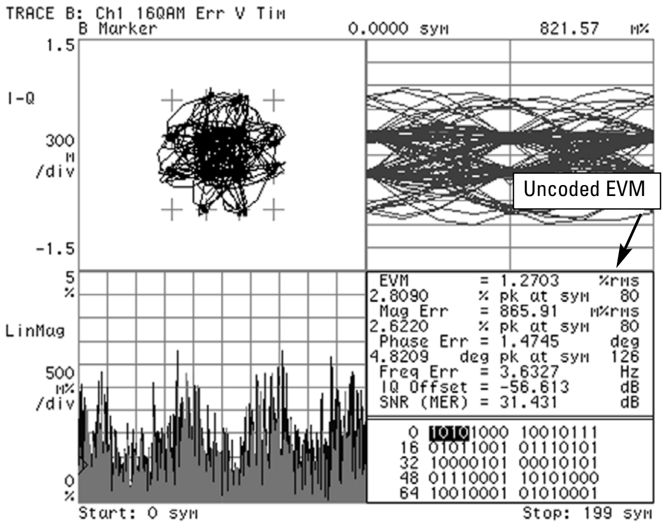


Figure 8. EVM measurement on a cdma2000 SR3 signal with pilot and sync channels, and one traffic channel (RC7 at 9.6 kpbs). All the channels have equal power level

- A cdma2000 signal with three channels at equal power level maps onto a 16 QAM constellation. For example, Figure 8 shows the polar diagram of an SR3 DS signal consisting of pilot and sync channels, and a single traffic channel. In this case, the corners of the 16 QAM constellation are missing due to the way the pilot and sync channels are combined.

Rho / EVM (coded)

Rho is a metric only used in CDMA systems. It is the ratio of the correlated power to the total power. The correlated power is typically calculated by performing a cross correlation between the measured signal and a known coded baseband signal (used as a reference), as specified by cdmaOne.

Unlike uncoded EVM, coded EVM is computed by comparing the measured signal to a known coded baseband signal. The difference between rho and coded EVM is that coded EVM calculates the error as the vector difference between the measured and reference signals, while rho performs a cross correlation between them.

Both rho and coded EVM account for all possible error mechanisms in the entire transmission chain of a CDMA transmitter, including coding problems, baseband filtering and timing errors, I/Q modulation anomalies, filter amplitude and phase non-linearities, and power amplifier distortions (see [1] for more information on rho).

The measurement setup for rho and coded EVM depends on the SR mode. SR1 and SR3 MC use a pilot with the same physical structure as cdmaOne. Since rho and coded EVM are typically measured on the pilot, any instrument with rho and coded EVM capability for cdmaOne can make these measurements on cdma2000 SR1 pilot signals, as shown in Figure 9.

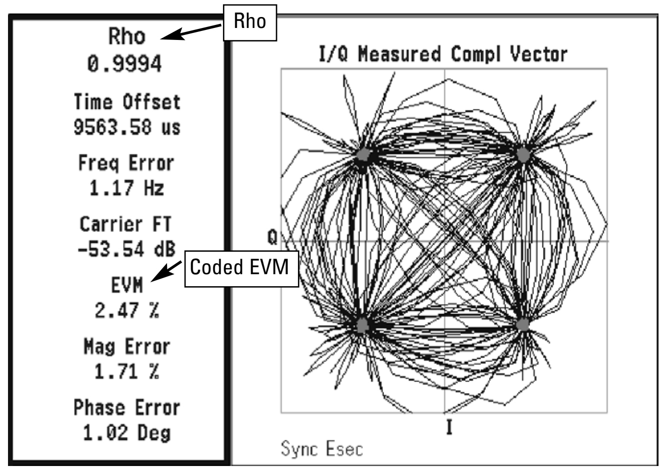


Figure 9. Rho and coded EVM measurement on a cdma2000 SR1 pilot signal

The same applies to SR3 MC. You can measure rho (and coded EVM) on the pilot for each carrier in the same way. However, interference from the adjacent carriers may degrade the measurement unless the measuring instrument filters it out.

In the case of SR3 DS, the pilot has a different coding structure than cdmaOne. Because the coding is different, the instrument cannot find correlation with the signal. Therefore, instruments with cdmaOne capability cannot perform these measurements[1].

1. There are several interpretations of rho. The 89400 series vector signal analyzers can make the measurement with certain assumptions (the measurement is not performed as specified by the cdmaOne standard).

Code-domain power

The other main indicator of modulation quality in CDMA systems is code-domain power. By using this measurement, you can verify that each Walsh channel is operating at its proper level, and quantify the inactive traffic noise level.

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. Table 1 shows the different Walsh code lengths for the different RCs that operate at SR1.

Table 1. Walsh code length for different RCs at SR1

RC	Walsh code length					
	128 bits (Walsh 128)	64 bits (Walsh 64)	32 bits (Walsh 32)	16 bits (Walsh 16)	8 bits (Walsh 8)	4 bits (Walsh 4)
1	N/A	9.6 kbps	N/A	N/A	N/A	N/A
2	N/A	14.4 kbps	N/A	N/A	N/A	N/A
3	N/A	9.6 kbps	19.2 kbps	38.4 kbps	76.8 kbps	153.6 kbps
4	9.6 kbps	19.2 kbps	38.4 kbps	76.8 kbps	153.6 kbps	307.2 kbps
5	N/A	14.4 kbps	28.8 kbps	56.7 kbps	115.2 kbps	203.4 kbps

One of the effects of using variable-length Walsh codes for spreading is that a shorter code precludes using all longer codes derived from it. Figure 10 illustrates this concept. If a high data rate channel using a four-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.

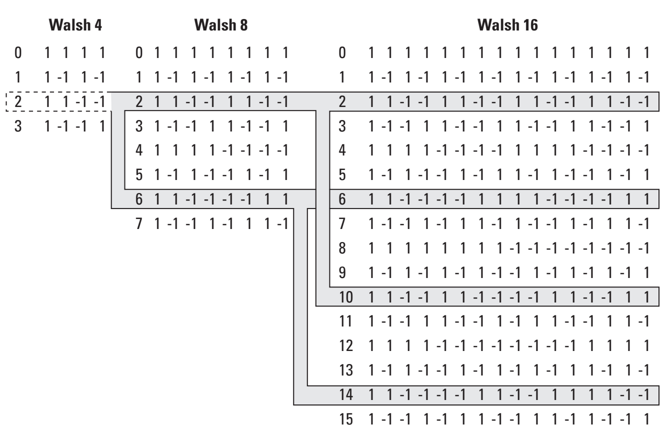


Figure 10. Hadamard generation of Walsh codes. Effects of using variable-length Walsh codes for spreading. Using a Walsh 4 code (in dashed box) precludes using codes in shaded area

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

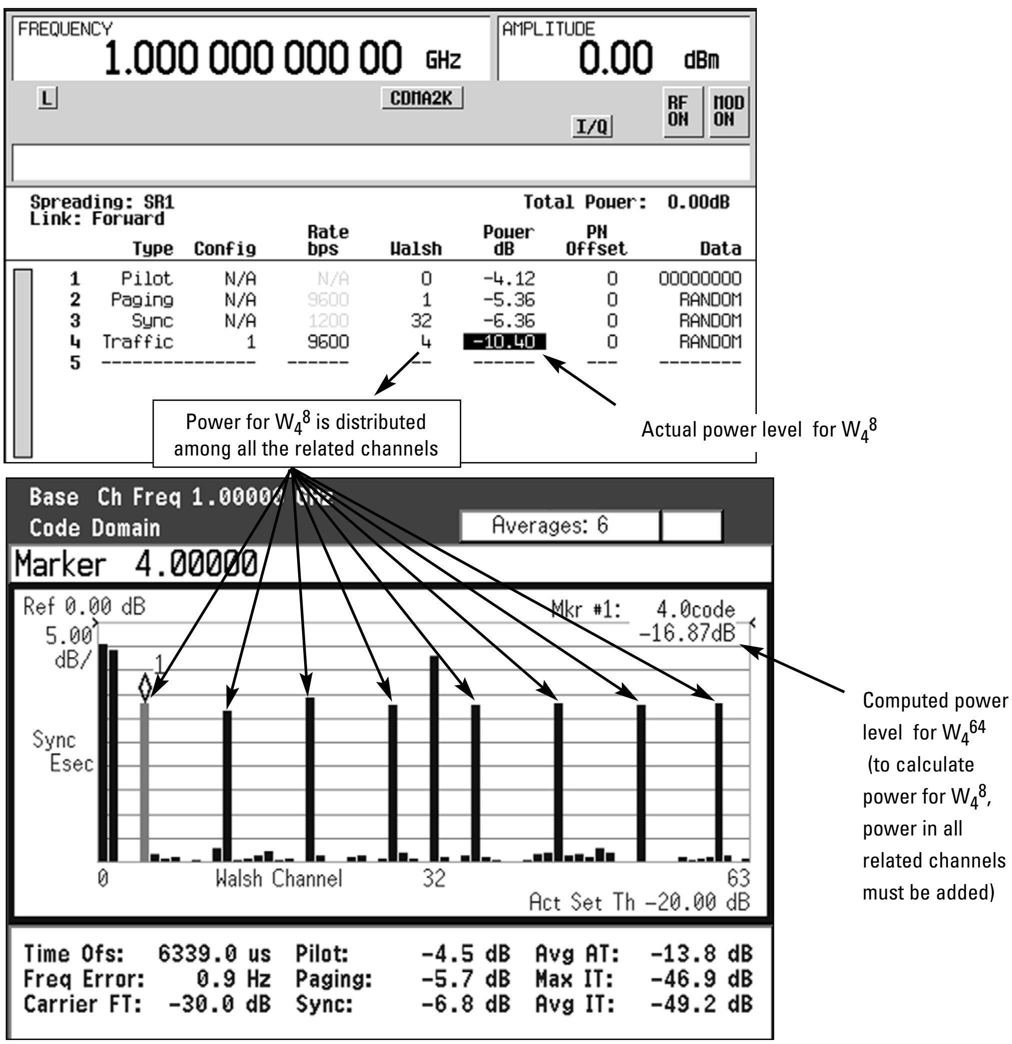
Therefore, W_2^4 precludes using:

- 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 6);
- and so forth.

Appendix A contains a cdma2000 Walsh code table that shows the relationships among Walsh codes of different lengths (determined by the data rate in a specific RC).

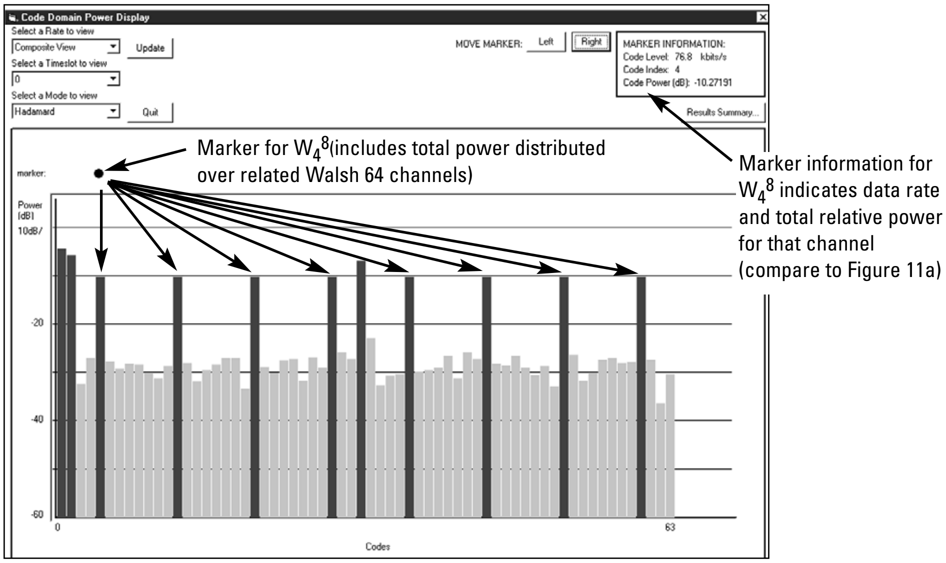
In the code-domain power measurement, channels with higher data rates (shorter code lengths) occupy more code space. For example, W24 occupies four times more code space than W_2^{16}, and sixteen times more code space than W_2^{64}. The measurement has to provide some way to identify the different layers (Walsh code lengths) and data rates of the code channels being measured.

You can use an instrument with cdmaOne capability to make code-domain power measurements on SR1 cdma2000 signals by taking some considerations into account. For an SR1 channel with Walsh code length different from cdmaOne (that is, a channel with a Walsh code shorter than 64 bits[1]), the detected power is spread onto all the Walsh 64 channels with a related Walsh code (a code that starts with the same sequence). Figure 11a shows the actual power levels for a cdma2000 signal with pilot, paging and sync channels and an RC3 channel with data rate of 76.8 kbps (W_4^8). Figure 11b shows the code-domain power measurement on that same signal. The power in W_4^8 is spread onto W_4^{64}, W_{12}^{64}, W_{20}^{64}, W_{28}^{64}, W_{36}^{64}, W_{44}^{64}, W_{52}^{64} and W_{60}^{64}. (You can use the cdma2000 Walsh code table in Appendix A to see the relationship between Walsh codes of different lengths). The total power of W48 in the code-domain power measurement can be calculated by adding the indicated power levels (in linear units) of all related Walsh 64 channels.



1. RC4 (9.6 kbps) is an exception to this. It is the only RC at SR1 that uses Walsh codes longer than 64 bits.

Therefore, code-domain power on SR1 cdma2000 signals can be measured using cdmaOne instrument capabilities. However, when multiple code channels with different data rates are active, the measurement process can become tedious. In any case, an instrument with specific cdma2000 capabilities offers many advantages, such as fast identification of channels with different data rates and accurate power readings for all channels. Figure 12 shows an example of a cdma2000 SR1 code-domain power measurement (performed using an instrument with code-domain power capability for cdma2000).



Similar considerations apply to SR3 MC signals. Additionally, in this case an instrument with code-domain power capability for cdmaOne can only make the measurement on a single carrier of the SR3 MC signal at a time.

Since SR3 DS uses a higher Spreading Rate, only instruments with specific code-domain power capability for cdma2000 can perform this measurement.

Modulation quality measurements—reverse link

The reverse link implementation in cdma2000 is very different from cdmaOne. In cdma2000, each mobile can transmit several channels. Channels can have different data rates and different power levels.

A multiple-channel signal typically has a higher peak-to-average power ratio than a single-channel signal. Therefore, it typically requires power amplifiers with a higher dynamic range. To solve this situation, cdma2000 uses QPSK modulation with a peak-limiting spreading function, HPSK—also known as OCQPSK (Orthogonal Complex Quadrature Phase Shift Keying). This allows for a less expensive output amplifier in the mobile.

These differences will have immediate consequences for the way modulation quality measurements are defined for the reverse link. For example, some sort of code-domain power and QPSK/HPSK demodulation/de-spreading may be necessary to provide the appropriate testing.

While the measurement methodology is being defined, you can use existing test instruments to obtain an indication of the modulation quality of your signal. The easiest methodology is to configure the signal so that it maps onto a known constellation (for instance, QPSK or 16QAM) and measure uncoded EVM[1]. The following are three suggested configurations:

- **QPSK constellation** (Figure 13): activate R-Pilot (Reverse Pilot) and R-FCH (Reverse Fundamental Channel) with equal power levels. Activating only the R-Pilot channel also produces a QPSK constellation.

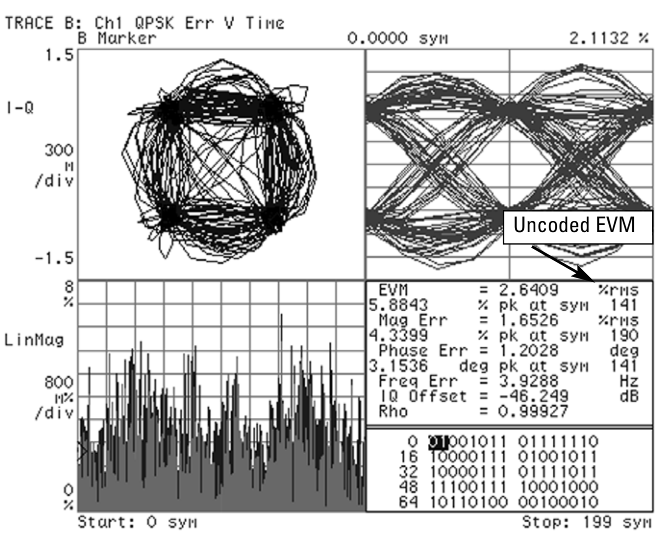


Figure 13. EVM (uncoded) on a cdma2000 SR1 reverse link signal with R-Pilot and R-FCH (RC3 at 9.6 kbps) activated. Both channels are at the same power level

- 8PSK (Figure 14): activate R-Pilot and R-FCH. Select the power level of the R-FCH 7.5 dB below the power level of the R-Pilot.

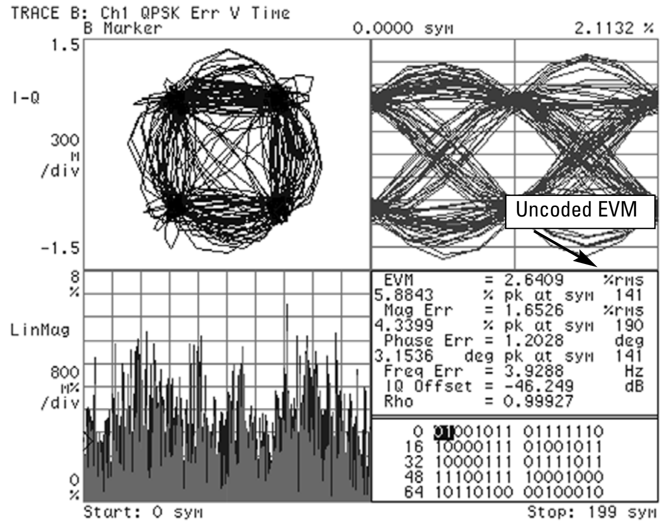


Figure 14. EVM (uncoded) on a cdma2000 SR1 reverse link signal with R-Pilot and R-FCH (RC3 at 9.6 kbps) activated. The power level for R-FCH is 7.5dB lower than level for R-Pilot

- 16 QAM (Figure 15): activate R-Pilot, R-FCH and R-SCH 1 (first supplemental channel). Select equal power for all channels.

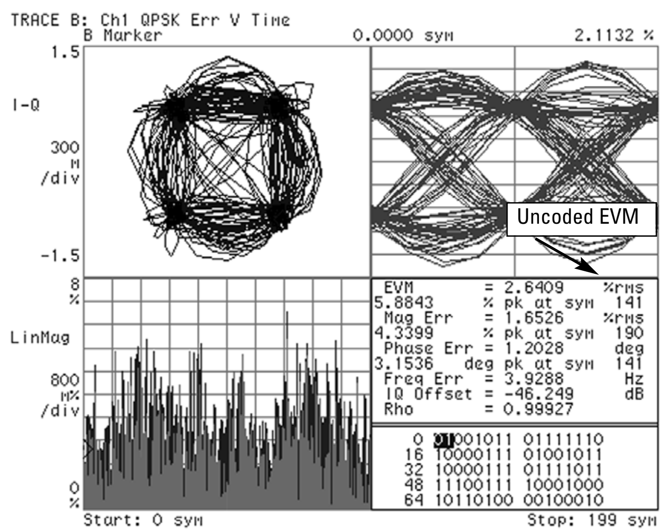


Figure 15. EVM (uncoded) on a cdma2000 SR1 reverse link signal with R-Pilot, R-FCH (RC3 at 9.6 kbps), and R-SCH 1 (RC3 at 307.2 kbps). All channels are at the same power level

1. Correct filtering parameters are required in the test instrument (filtering parameters for cdmaOne mobile stations can be used).

HPSK

In the reverse link, the different channels are assigned to either the I or Q paths. For example, for RC3 to RC6, R-Pilot (Reverse Pilot) is assigned to I, and R-FCH (Reverse Fundamental Channel) is assigned to Q (see Figure 16).

Channels can be at different rates and different power levels. Complex scrambling facilitates this by continuously rotating the phase of the constellation, distributing the power evenly between the axes. Without scrambling, unequal channel powers would result in a rectangular 4 QAM constellation (assuming that only R-Pilot and R-FCH are active). With complex scrambling, the constellation generally has eight points distributed around a circle; the angular distribution being determined by the relative powers of the two channels. If the channel powers are equal, then pairs of constellation points merge to give a QPSK-like constellation. For example, Figure 13 shows the constellation of an SR1 signal with the R-Pilot and R-FCH channels at the same power level. Figure 14 shows the constellation of a signal with the R-FCH 7.5 dB below the R-Pilot level.

Basic complex scrambling applies a phase rotation of 0, $\pm\pi/2$, or p radians to each chip. HPSK takes this a stage further and defines the complex scrambling in such a way that for every second chip, the phase rotation is restricted to $\pm\pi/2$. This constraint on the phase transitions entering the baseband filter reduces the peak-to-average ratio of the signal (by 1 to 1.5 dB). The HPSK technique continues to be advantageous even when the signal has more than two channels.

3. Summary

Cdma2000 is the 3GPP2 standard for 3G technology derived from cdmaOne. Although the standard has not yet been defined, R&D component and system engineers need to test their cdma 2000 designs today. This application note is a guide to cdma2000 testing based on established cdmaOne measurements.

As the standards continue to evolve, Agilent application information, design tools and test equipment will keep pace with the changes to help you achieve your product development goals.

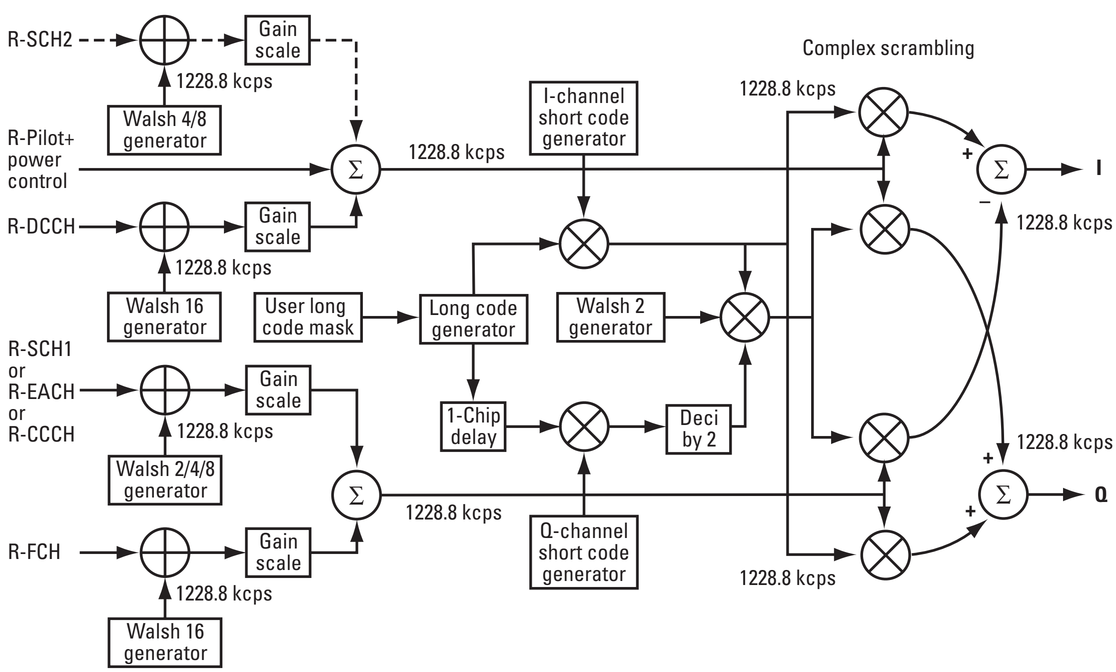


Figure 16. Channel summing and HPSK spreading in cdma2000 reverse link (SR1)

4. Appendix A: cdma2000 Walsh code table

Table 2 shows the relationship between Walsh codes of different lengths for the different RCs at different data rates. The energy in a channel with a shorter code correlates into all channels with longer related codes. Therefore, a shorter code precludes using all longer codes derived from it (from right to left in the table). For example, RC3 at 76.8 kbps uses Walsh 8 codes. W48 precludes using the codes in the shaded area (see Figure 17):

- W_4^{16}, W_{12}^{16};
- W_4^{32}, W_{12}^{32}, W_{20}^{32}, W_{28}^{32};
- W_4^{64}, W_{12}^{64}, W_{20}^{64}, W_{28}^{64}, W_{36}^{64}, W_{44}^{64}, W_{52}^{64}, W_{60}^{64};
- and so forth.

Spread rate	RC	cdma2000 Walsh Code Table						
1.2288 Mcps	1	N/A	N/A	9.6 kbps	N/A	N/A	N/A	N/A
1.2288 Mcps	2	N/A	N/A	14.4 kbps	N/A	N/A	N/A	N/A
1.2288 Mcps	3	N/A	N/A	9.6 kbps	19.2 kbps	38.4 kbps	76.8 kbps	153.6 kbps
1.2288 Mcps	4	N/A	9.6 kbps	19.2 kbps	38.4 kbps	76.8 kbps	153.6 kbps	307.2 kbps
1.2288 Mcps	5	N/A	N/A	14.4 kbps	28.8 kbps	56.7 kbps	115.2 kbps	230.4 kbps
3.6864 Mcps	6	N/A	9.6 kbps	19.2 kbps	38.4 kbps	76.8 kbps	153.6 kbps	307.2 kbps
3.6864 Mcps	7	9.6 kbps	19.2 kbps	38.4 kbps	76.8 kbps	153.6 kbps	307.2 kbps	614.4 kbps
3.6864 Mcps	8	N/A	14.4 kbps	28.8 kbps	56.7 kbps	115.2 kbps	230.4 kbps	460.8 kbps
3.6864 Mcps	9	14.4 kbps	28.8 kbps	56.7 kbps	115.2 kbps	230.4 kbps	460.8 kbps	1036.8 kbps
		Walsh 256	Walsh 128	Walsh 64	Walsh 32	Walsh 16	Walsh 8	Walsh 4
		0	0	0	0	0	0	0
		128						
		64	64					
		192						
		32	32	32				
		120	120					
		248						
		4	4	4	4	4	4	
		132						
		68	68					
		196						
		36	36	36				
		164						
		100	100					
		228						
		20	20	20	20			
		148						
		84	84					
		212						
		52	52	52				
		180						
		116	116					
		244						
		12	12	12	12	12		
		140						
		76	76					
		204						
		44	44	44				
		172						
		108	108					
		236						
		28	28	28	28			
		156						
		92	92					
		220						
		60	60	60				
		188						
		124	124					
		252						

W_4^{16}

W_4^8

W_{12}^{16}

Figure 17. Using W_4^8 precludes the codes in the shaded area.

Table 2. cdma2000 Walsh code table

Spread rate	RC	cdma2000 Walsh Code Table						
1.2288 Mcps	1	N/A	N/A	9.6 kbps	N/A	N/A	N/A	N/A
1.2288 Mcps	2	N/A	N/A	14.4 kbps	N/A	N/A	N/A	N/A
1.2288 Mcps	3	N/A	N/A	9.6 kbps	19.2 kbps	38.4 kbps	76.8 kbps	153.6 kbps
1.2288 Mcps	4	N/A	9.6 kbps	19.2 kbps	38.4 kbps	76.8 kbps	153.6 kbps	307.2 kbps
1.2288 Mcps	5	N/A	N/A	14.4 kbps	28.8 kbps	56.7 kbps	115.2 kbps	230.4 kbps
3.6864 Mcps	6	N/A	9.6 kbps	19.2 kbps	38.4 kbps	76.8 kbps	153.6 kbps	307.2 kbps
3.6864 Mcps	7	9.6 kbps	19.2 kbps	38.4 kbps	76.8 kbps	153.6 kbps	307.2 kbps	614.4 kbps
3.6864 Mcps	8	N/A	14.4 kbps	28.8 kbps	56.7 kbps	115.2 kbps	230.4 kbps	460.8 kbps
3.6864 Mcps	9	14.4 kbps	28.8 kbps	56.7 kbps	115.2 kbps	230.4 kbps	460.8 kbps	1036.8 kbps
		Walsh 256	Walsh 128	Walsh 64	Walsh 32	Walsh 16	Walsh 8	Walsh 4
		0	0	0	0	0	0	0
		128						
		64	64					
		192						
		32	32	32				
		160						
		96	96					
		224						
		16	16	16	16			
		144						
		80	80					
		208						
		48	48	48				
		176						
		112	112					
		240						
		8	8	8	8	8		
		136						
		72	72					
		200						
		40	40	40				
		168						
		104	104					
		232						
		24	24	24	24			
		152						
		88	88					
		216						
		56	56	56				
		184						
		120	120					
		248						
		4	4	4	4	4	4	
		132						
		68	68					
		196						
		36	36	36				
		164						
		100	100					
		228						
		20	20	20	20			
		148						
		84	84					
		212						
		52	52	52				
		180						
		116	116					
		244						
		12	12	12	12	12		
		140						
		76	76					
		204						
		44	44	44				
		172						
		108	108					
		236						
		28	28	28	28			
		156						
		92	92					
		220						
		60	60	60				
		188						
		124	124					
		252						

cdma2000 Walsh Code Table

Spread rate	RC							
1.2288 Mcps	1	N/A	N/A	9.6 kbps	N/A	N/A	N/A	N/A
1.2288 Mcps	2	N/A	N/A	14.4 kbps	N/A	N/A	N/A	N/A
1.2288 Mcps	3	N/A	N/A	9.6 kbps	19.2 kbps	38.4 kbps	76.8 kbps	153.6 kbps
1.2288 Mcps	4	N/A	9.6 kbps	19.2 kbps	38.4 kbps	76.8 kbps	153.6 kbps	307.2 kbps
1.2288 Mcps	5	N/A	N/A	14.4 kbps	28.8 kbps	56.7 kbps	115.2 kbps	230.4 kbps
3.6864 Mcps	6	N/A	9.6 kbps	19.2 kbps	38.4 kbps	76.8 kbps	153.6 kbps	307.2 kbps
3.6864 Mcps	7	9.6 kbps	19.2 kbps	38.4 kbps	76.8 kbps	153.6 kbps	307.2 kbps	614.4 kbps
3.6864 Mcps	8	N/A	14.4 kbps	28.8 kbps	56.7 kbps	115.2 kbps	230.4 kbps	460.8 kbps
3.6864 Mcps	9	14.4 kbps	28.8 kbps	56.7 kbps	115.2 kbps	230.4 kbps	460.8 kbps	1036.8 kbps
		Walsh 256	Walsh 128	Walsh 64	Walsh 32	Walsh 16	Walsh 8	Walsh 4
		1	1	1	1	1	1	1
		129						
		65	65					
		193						
		33	33	33				
		161						
		97	97					
		225						
		17	17	17	17			
		145						
		81	81					
		209						
		49	49	49				
		177						
		113	113					
		241						
		9	9	9	9	9		
		137						
		73	73					
		201						
		41	41	41				
		169						
		105	105					
		233						
		25	25	25	25			
		153						
		89	89					
		217						
		57	57	57				
		185						
		121	121					
		249						
		5	5	5	5	5	5	
		133						
		69	69					
		197						
		37	37	37				
		165						
		101	101					
		229						
		21	21	21	21			
		149						
		85	85					
		213						
		53	53	53				
		181						
		117	117					
		245						
		13	13	13	13	13		
		141						
		77	77					
		205						
		45	45	45				
		173						
		109	109					
		237						
		29	29	29	29			
		157						
		93	93					
		221						
		61	661	61				
		189						
		125	125					
		253						

Spread rate	RC	cdma2000 Walsh Code Table						
1.2288 Mcps	1	N/A	N/A	9.6 kbps	N/A	N/A	N/A	N/A
1.2288 Mcps	2	N/A	N/A	14.4 kbps	N/A	N/A	N/A	N/A
1.2288 Mcps	3	N/A	N/A	9.6 kbps	19.2 kbps	38.4 kbps	76.8 kbps	153.6 kbps
1.2288 Mcps	4	N/A	9.6 kbps	19.2 kbps	38.4 kbps	76.8 kbps	153.6 kbps	307.2 kbps
1.2288 Mcps	5	N/A	N/A	14.4 kbps	28.8 kbps	56.7 kbps	115.2 kbps	230.4 kbps
3.6864 Mcps	6	N/A	9.6 kbps	19.2 kbps	38.4 kbps	76.8 kbps	153.6 kbps	307.2 kbps
3.6864 Mcps	7	9.6 kbps	19.2 kbps	38.4 kbps	76.8 kbps	153.6 kbps	307.2 kbps	614.4 kbps
3.6864 Mcps	8	N/A	14.4 kbps	28.8 kbps	56.7 kbps	115.2 kbps	230.4 kbps	460.8 kbps
3.6864 Mcps	9	14.4 kbps	28.8 kbps	56.7 kbps	115.2 kbps	230.4 kbps	460.8 kbps	1036.8 kbps
		Walsh 256	Walsh 128	Walsh 64	Walsh 32	Walsh 16	Walsh 8	Walsh 4
		2	2	2	2	2	2	2
		130						
		66	66					
		194						
		34	34	34				
		162						
		98	98					
		226						
		18	18	18	18			
		146						
		82	82					
		210						
		50	50	50				
		178						
		114	114					
		242						
		10	10	10	10	10		
		138						
		74	74					
		202						
		42	42	42				
		170						
		106	106					
		234						
		26	26	26	26			
		154						
		90	90					
		218						
		58	58	58				
		186						
		122	122					
		250						
		6	6	6	6	6	6	
		134						
		70	70					
		198						
		38	38	38				
		166						
		102	102					
		230						
		22	22	22	22			
		150						
		86	86					
		214						
		54	54	54				
		182						
		118	118					
		246						
		14	14	14	14	14		
		142						
		78	78					
		206						
		46	46	46				
		174						
		110	110					
		238						
		30	30	30	30			
		158						
		94	94					
		222						
		62	62	62				
		190						
		126	126					
		254						

Spread rate	RC	cdma2000 Walsh Code Table						
1.2288 Mcps	1	N/A	N/A	9.6 kbps	N/A	N/A	N/A	N/A
1.2288 Mcps	2	N/A	N/A	14.4 kbps	N/A	N/A	N/A	N/A
1.2288 Mcps	3	N/A	N/A	9.6 kbps	19.2 kbps	38.4 kbps	76.8 kbps	153.6 kbps
1.2288 Mcps	4	N/A	9.6 kbps	19.2 kbps	38.4 kbps	76.8 kbps	153.6 kbps	307.2 kbps
1.2288 Mcps	5	N/A	N/A	14.4 kbps	28.8 kbps	56.7 kbps	115.2 kbps	230.4 kbps
3.6864 Mcps	6	N/A	9.6 kbps	19.2 kbps	38.4 kbps	76.8 kbps	153.6 kbps	307.2 kbps
3.6864 Mcps	7	9.6 kbps	19.2 kbps	38.4 kbps	76.8 kbps	153.6 kbps	307.2 kbps	614.4 kbps
3.6864 Mcps	8	N/A	14.4 kbps	28.8 kbps	56.7 kbps	115.2 kbps	230.4 kbps	460.8 kbps
3.6864 Mcps	9	14.4 kbps	28.8 kbps	56.7 kbps	115.2 kbps	230.4 kbps	460.8 kbps	1036.8 kbps
		Walsh 256	Walsh 128	Walsh 64	Walsh 32	Walsh 16	Walsh 8	Walsh 4
		3	3	3	3	3	3	3
		131						
		67	67					
		195						
		35	35	35				
		163						
		99	99					
		227						
		19	19	19	19			
		147						
		83	83					
		211						
		51	51	51				
		179						
		115	115					
		243						
		11	11	11	11	11		
		139						
		75	75					
		203						
		43	43	43				
		171						
		107	107					
		235						
		27	27	27	27			
		155						
		91	91					
		219						
		59	59	59				
		187						
		123	123					
		251						
		7	7	7	7	7	7	
		135						
		71	71					
		199						
		39	39	39				
		167						
		103	103					
		231						
		23	23	23	23			
		151						
		87	87					
		215						
		55	55	55				
		183						
		119	119					
		247						
		15	15	15	15	15		
		143						
		79	79					
		207						
		47	47	47				
		175						
		111	111					
		239						
		31	31	31	31			
		159						
		95	95					
		223						
		63	63	63				
		191						
		127	127					
		255						

5. Appendix B: Agilent solutions for cdma2000

Signal generation

This section provides a list of Agilent equipment that you can use to make measurements on your cdma2000 components and systems today.

The Agilent ESG-D series RF signal generators with Option 101 have the capability of simulating statistically-correct forward and reverse link cdma2000 signals for component testing#1. An easy-to-use interface allows you to:

`
- select the Spreading Rate (SR1 or SR3)
- choose multicarrier or direct spread in the forward link;
- use QPSK/HPSK modulation/spreading in the reverse link;
- select from several predefined cdma2000 multi-channel signals; or
- use the table editor to fully configure a cdma2000 multi-channel signal per your requirements.

1. cdma2000 forward and reverse link signals for receiver measurements will be available in the future in the Agilent ESG-D series RF signal generators

Signal analysis

Table 3 provides a list of Agilent signal analyzers that have cdma2000 measurement capabilities today (as of 6/99).

Table 3. Agilent instrument capabilities for cdma2000

cdma2000		**Agilent Instruments**				
		Vector signal analyzers		Spectrum analyzers		
Measurements		VSA series transmitter tester[1]	89400A series vector signal analyzers[2]	8560 E-series spectrum analyzers[3]	8590 E-series with measurement personality[2]	ESA-E series spectrum analyzers[3]
Channel power		●	●	●	●	●
Occupied bandwidth			●	●	●	●
In-band Emissions	ACPR[4]	●	●	●[5]	●	●[5]
	In-band spurious	●[13]	●[6]	●	●	●[6]
Out-of-band spurious/harmonics		up to 4 GHz[6]	up to 2.6 GHz[6]	●	●	●[6]
Peak/average power ratio		●	●		●	
CCDF		●	●			
Modulation quality—forward link	EVM (uncoded)	●[7]	●[8]			
	Rho/EVM (coded)	●[9]	●[10]			
	I/Q Offset	●	●			
	Frequency accuracy	●	●			
	Code-domain power	●[11]				
Modulation quality—reverse link	EVM (uncoded)	●[7]	●[8]			
	Rho/EVM (coded)	●[12]	●[10]			

Notes:

1. Measurement pre-configured for cdma2000.
2. Some measurements pre-configured for cdmaOne. Measurement parameters can be manually changed to accommodate cdma2000.
3. Measurements are not pre-configured to a specific standard. Measurement parameters can be manually selected to accommodate cdma2000.
4. ACPR measurement is not part of cdmaOne standard specifications. However, individual NEMs typically specify ACPR as a figure of merit for component testing. This may also apply to cdma2000.
5. Measurement can be performed if same integration bandwidth is used for main channel and offsets. Power (or rms) averaging is not available. The Agilent ESA-E series is targeted at service applications.
6. Manual measurement (no automatic spurious search).
7. Measurement can be performed if the reverse link configuration forms a QPSK constellation. See related sections in the application note for more detail.
8. Measurement can be performed if the reverse link configuration forms a "conventional" constellation. See related sections in the application note for more detail.
9. Only available for SR1 and SR3 MC.
10. There are several interpretations of rho. The 89400 series vector signal analyzers can make the rho measurement with certain assumptions. Coded EVM is not available in this instrument.
11. Available in an external PC.
12. RC1 and RC2 only.
13. Pre-configured for cdmaOne. Measurement parameters can be manually selected to accommodate cdma2000.

6. Glossary

2G	Second Generation
3G	Third Generation
3GPP2	Third-Generation Partnership Project 2
ACPR	Adjacent Channel Power Ratio
ARIB	Japanese Association of Radio Industries and Businesses
BPSK	Binary Phase Shift Keying
CCDF	Complementary Cumulative Distribution Function
CDMA	Code Domain Multiple Access
cdmaOne	IS-95 standard-based CDMA system
cdma2000	cdmaOne derivative, 3G proposal
DS	Direct Spectrum
EVM	Error Vector Magnitude
HPSK	Hybrid Phase Shift Keying
IF	Intermediate Frequency
IMT-2000	International Mobile Telecommunications-2000
I/Q	In-phase/Quadrature
IS-95	Interim Standard for US Code Division Multiple Access
MC	Multiple Carrier
NEM	Network Equipment Manufacturer
OCQPSK	Orthogonal Complex Quadrature Phase Shift Keying
OQPSK	Offset Quadrature Phase Shift Keying
PSK	Phase Shift Keying
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
RC	Radio Configuration
RF	Radio Frequency
R-CCCH	Reverse-Common Control Channel
R-DCCH	Reverse-Dedicated Control Channel
R-EACH	Reverse-Enhanced Access Channel
R-FCH	Reverse-Fundamental Channel
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

7. References

[1] *Understanding CDMA Measurements for Base Stations and Their Components*, Application Note 1311, literature number 5968-0953E.

[2] Ken Thompson, *Concepts of cdma2000*, Wireless Symposium, 1999.

[3] *Testing and Troubleshooting Digital RF Communications Transmitter Designs*, Application Note 1313, literature number 5968-3578E.

[4] Pete Watridge, *Power Statistics of Digitally Modulated Signals*, Wireless Symposium, 1999.

8. Related Literature

1. *ESG Series RF Digital and Analog Signal Generators*, literature number 5966-3596E.
2. *VSA Series Transmitter Tester*, literature number 5966-4762E.
3. *Building the Wireless Future... With You* (VSA Series Transmitter Tester), literature number 5968-5259E.
4. *89400 Series Vector Signal Analyzers*, literature number 5965-8554E.
5. *8560 E-Series Spectrum Analyzers*, literature number 5966-3559E.
6. *8590 E-Series Spectrum Analyzers*, literature number 5963-6908E.
7. *ESA-E Series Spectrum Analyzers*, literature number 5968-3278E.

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