Agilent
PSA Series Spectrum Analyzers Self-Guided Demonstration for cdma2000 Measurements

Product Note

This demonstration guide is a tool to help you gain familiarity with the basic functions and important features of the Agilent PSA series spectrum analyzers. Because the PSA series offers expansive functionality, the demonstration guide is available in several pieces. This portion introduces the advanced, one-button power measurements and digital demodulation capability of the cdma2000 measurement personality (Option B78). All portions of the self-guided demonstration are listed in the product literature section at the end of this guide and can also be found at

http://www.agilent.com/find/psa

All exercises in this demonstration utilize the E4438C ESG vector signal generator. Keystrokes surrounded by [ ] indicate *hard* keys located on the front panel, while key names surrounded by { } indicate *soft* keys located on the right edge of the display.

Agilent Technologies

Table of contents

About the PSA series

The Agilent PSA series is a family of modern, high-performance spectrum analyzers with digital demodulation and one-button measurement personalities for 2G/3G applications. It offers an exceptional combination of dynamic range, accuracy, and measurement speed. The PSA delivers the highest level of measurement performance available in Agilent spectrum analyzers. An all-digital IF section includes fast Fourier transform (FFT) analysis and a digital implementation of a swept IF. The digital IF and innovative analog design provide much higher measurement accuracy and improved dynamic range compared to traditional spectrum analyzers. This performance is combined with measurement speed typically 2 to 50 times faster than spectrum analyzers using analog IF filters.

The PSA series complements Agilent's other spectrum analyzers such as the ESA series, a family of mid-performance analyzers that cover a variety of RF and microwave frequency ranges while offering a great combination of features, performance, and value.

Part 1
Demonstration preparation

The following options are required for the ESG and the PSA series.

Product type	Model number	Required options
ESG vector signal generator	E4438C	502, 503, 504, or 506 – frequency range up to at least 2 GHz 001 or 002 – baseband generator 401 – cdma2000 and IS95A personalities
PSA series spectrum analyzer	E4440A/E4443A/E4445A/ E4446A/E4448A	B7J – Digital demodulation hardware B78 – cdma2000 measurement personality

To configure these instruments, simply connect the ESG's 50 Ω RF output to the PSA's 50 Ω RF input with a 50 Ω RF cable. Turn on the power in both instruments.

Now set up the ESG to provide a cdma2000 signal with nine channels.

Instructions	Keystrokes
On the ESG:	
Set the carrier frequency to 1 GHz.	[Preset] [Frequency] [1] {GHz}
Set amplitude to -10 dBm.	[Amplitude] [-10] {dBm}
Select cdma2000 mode.	[Mode] {CDMA} {Arb CDMA2000}
Generate a cdma2000 Spread Rate 1 signal.	{Spread Rate} {Spread Rate 1}
Select the channel structure.	{CDMA2000 Select} {9 Channel}
Change the data rate and Walsh code of a supplemental 1 traffic channel.	{More} {CDMA2000 Define} {Edit Channel Setup}, tab to Row 5 under "Walsh", {Edit Item} [5] {Enter}, tab to Row 5 under "Rate bps", {Edit Item} {More} {76800 Bps} [Return] {Apply Channel Setup} [Return] {More}
Activate the format.	{cdma2000 On} [RF On]

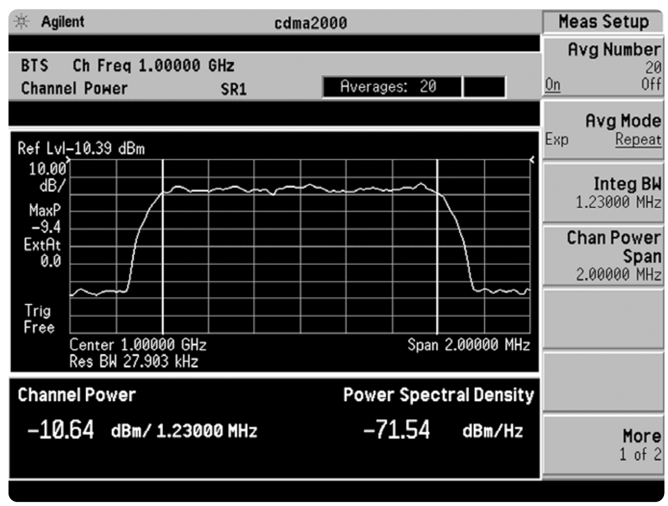
Part 2
Channel power

The channel power measurement measures the channel power within a specified bandwidth (default of 1.23 MHz) and the power spectral density (PSD) in dBm/Hz.

This exercise demonstrates the one-button channel power measurement on the PSA.

Instructions	Keystrokes
On the PSA:	
Perform factory preset.	[System] {Power On/Preset} {Preset Type} {Factory}
Enter the cdma2000 mode in the analyzer.	[Preset] [Mode] ({More} if necessary}) {cdma2000}
Choose transmitter device. The PSA can make measurements on both the forward and reverse links, but only the forward link will be demonstrated in this guide.	[Mode Setup] {Radio} {Device BTS}
Activate channel power measurement. Observe the white bars indicating the spectrum channel width and the quantitative values given beneath.	[MEASURE] {Channel Power}
Examine settings (figure 1). Use this step to make setup changes in any measurement.	[Meas Setup]

Figure 1.
Channel power



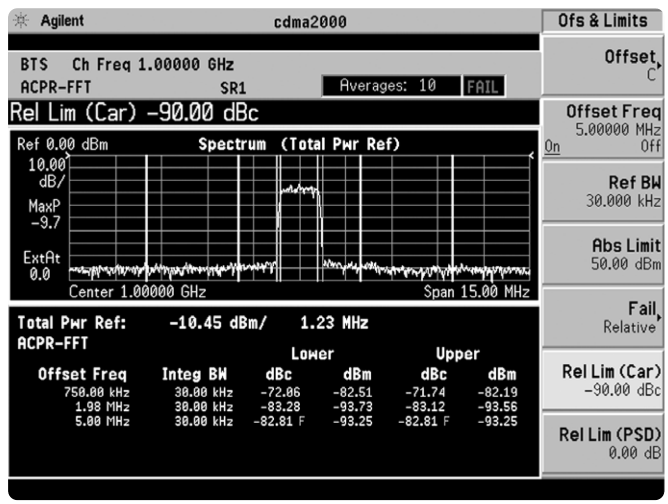
Part 3
Adjacent channel power ratio (ACPR)

Reducing transmitter channel leakage allows for more channels to be transmitted simultaneously, which, in turn, increases base station efficiency. The ACPR is a measure of the power in adjacent channels relative to the transmitted power. The cdma2000 ACPR measurement performed in this exercise can measure up to five adjacent channel pairs.

In this exercise, the ACPR measurement will be made and the customizable offsets and limits explored.

Instructions	Keystrokes
On the PSA:	
Activate ACPR measurement.	[MEASURE] {ACPR}
Enable spectrum view.	[Trace/View] {Spectrum}
Expand spectrum display. Use this to expand any window in any measurement.	[Next Window] until spectrum display is highlighted in green, [Zoom] ([Zoom] again to return)
Add an offset and set its limit (figure 2). Notice as the green PASS indicator in the upper right corner changes to a red FAIL when the signal does not meet limit requirements.	[Meas Setup] {Ofs & Limits} {Offset} {C} {Offset Freq On} [5] {MHz} {Rel Lim (Car)} [-90] {dBc}

Figure 2.
Multi-offset ACPR



Part 4
Spectrum emission mask

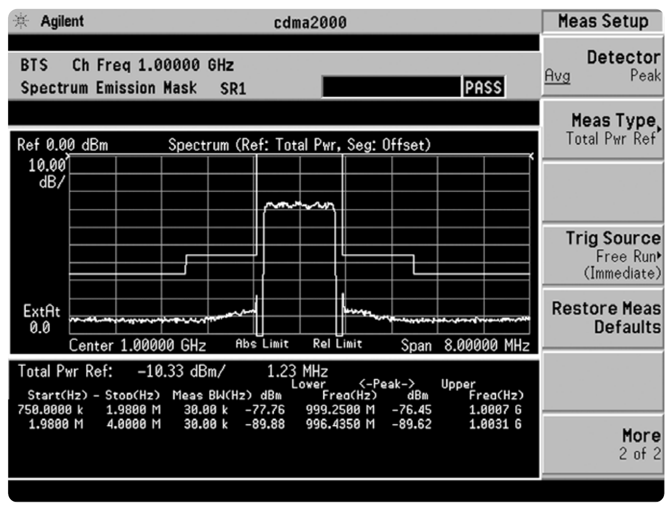
The recommended performance standards for cdma2000 have specific limits for transmitted spurious emissions. This measurement has different limits for different frequency offsets measured in different resolution bandwidths. Completing this measurement with a traditional spectrum analyzer can be tedious and time consuming. The PSA makes this measurement with one button press.

This exercise illustrates the spectrum emission mask measurement and explores some of the customizable features. Notice in the PSA measurement that the mask limit is represented by a green trace on the screen.

Note:
Because the PSA series performs fast Fourier transforms (FFT) for this measurement, the local oscillator (LO) steps in discrete frequency increments. (The step size is assigned under [Meas Setup] {Offset/Limits} {Step Freq}.) A measurement is made at each frequency point; offset segments group the points. For each segment, the resolution bandwidth can be individually specified. The step frequency ({Step Freq}) and resolution bandwidth ({Res BW}) default to coupled mode. When these parameters are set manually, it is essential that that the resolution bandwidth be larger than the step size. If not, some signal components will be missed when they fall between successive peaks of the resolution bandwidth filter. In fact, it is good practice to make the resolution bandwidth twice as wide as the step size given that the filter is Gaussian. This ensures that successive filter bandwidth steps will overlap.

Instructions	Keystrokes
On the PSA:	
Activate the spectrum emission mask measurement. Observe the mask and trace in the upper window and the table of measured values in the lower window.	[MEASURE] {Spectrum Emission Mask}
Choose the type of values to display. Observe the measurement values change in the lower window to reflect the selected value type.	[Display], choose {Abs Peak Pwr & Freq}, {Rel Peak Pwr & Freq} or {Integrated Power}
View customizable offsets and limits. Measurement parameters as well as limit values may be customized for any of the five offset pairs or for any individual offset.	[Meas Setup] {Offset/Limits} {More} {Limits}
Specify measurement interval (up to 10 ms) and select detector type (average or peak) (figure 3).	[Meas Setup] {Meas Interval}, rotate KNOB, [⇑] or [⇓], {More}, toggle {Detector}

Figure 3.
Spectrum emission mask



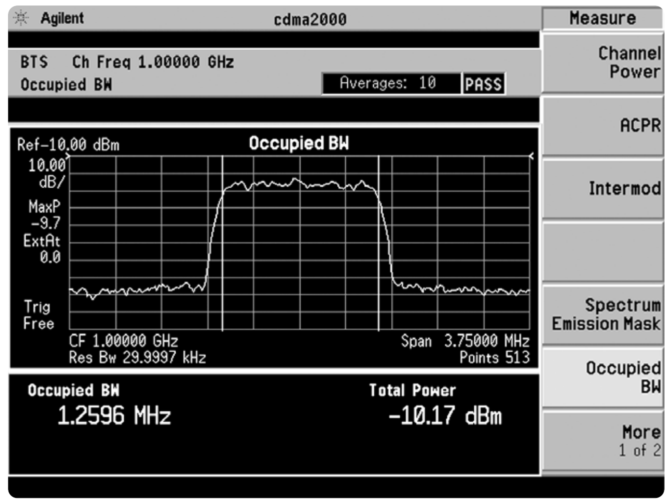
Part 5
Occupied bandwidth

Occupied bandwidth is a measure of the frequency range that has 0.5 percent of the total radiated power above and below it. In other words, it determines the frequency bandwidth that that contains 99 percent of the total radiated power.

In this measurement, the total power of the displayed span is measured. Then the power is measured inward from the right and left extremes until 0.5 percent of the power is accounted for in each of the upper and lower parts of the span. The calculated difference is the occupied bandwidth. For simple setup, the PSA defaults to a 1.48-MHz PASS/FAIL limit value.

Instructions	Keystrokes
On the PSA:	
Measure the occupied bandwidth (figure 4).	[MEASURE] {Occupied BW}

Figure 4.
Occupied bandwidth



Part 6
Code domain analysis

The code domain analysis measurement provides a variety of different results. First, code domain power analysis measures the distribution of signal power across the set of code channels, normalized to the total signal power. This measurement helps to verify that each code channel is operating at its proper level and to identify problems throughout the transmitter design from the coding to the RF section. System imperfections, such as amplifier non-linearity, will present themselves as an undesired distribution of power in the code domain.

Unlike cdmaOne, cdma2000 uses Walsh codes of different lengths. Channels with shorter code lengths (higher data rates) occupy more code space. For example, 8-bit Walsh codes occupy eight times more code space than 64-bit Walsh codes. However, the code space used for channels with shorter code lengths is not contiguous. The bit-reverse generation of Walsh channels provides the desired code number assignments to uniformly distribute the code space.

There are two algorithms by which the PSA can display the code channel power. First is the Hadamard algorithm, which displays each Walsh code in sequence. When a marker is applied and the "Consolidated Marker" feature is activated (default condition), the dark and light blue bars on the display are the composite representation of the traffic channel. When the "Consolidated Marker" feature is turned off, the channel power corresponds to the selected Walsh code only.

The bit-reverse algorithm displays the channels as consolidated code space. The PSA shows a bar for each channel with the bar height proportionately representative of the channel power and the bar width proportional to the data rate.

Now examine the cdma2000 signal using each of the algorithms.

Instructions	Keystrokes
On the PSA:	
Activate the code domain measurement.	[MEASURE] {More} {Code Domain}
Use the marker to examine Walsh code 5 using the Hadamard algorithm (figure 5).* Notice the dark and light blue bars as part of the consolidated marker. The marker values indicate the power for a Walsh 8 channel.	[Marker] [5] [Enter]
Change the Walsh code algorithm to bit-reverse and examine the new result (figure 6).	[Display] {Code Order Bit Reverse}, rotate KNOB to highlight widest Walsh channel

Figure 5.
Code domain power in Hadamard code order

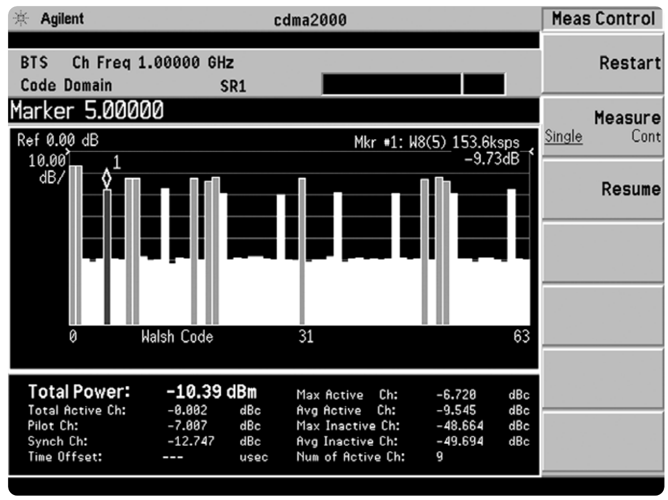
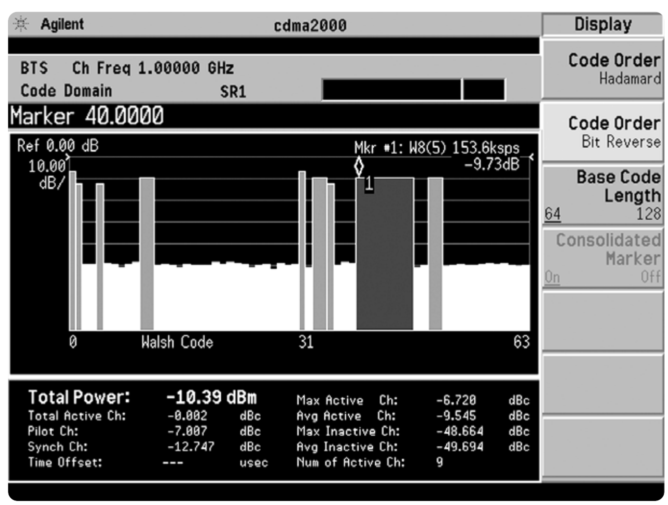


Figure 6.
Code domain power in bit-reverse code order



*The data rate programmed into the ESG may seem different than that measured with the PSA. In actuality, they are the same. The ESG gives the data rate in bits per second, while the PSA measures the data rate in symbols per second. The data rates are related through the radio configuration and the spreading rate.

Additionally, the PSA will de-spread any single code channel to provide magnitude and phase error data, EVM data, symbol power versus time plots, symbol polar vector plots, and demodulated (but not decoded) I and Q bits.

In this section, explore the many means by which to examine code domain data.

Instructions	Keystrokes
On the PSA:	
Change the Walsh code algorithm back to Hadamard and put the marker on Walsh code 17.	[Display] {Code Order Hadamard} {Marker} [17] [Enter]
Run single measurement.	[Single]
View magnitude error, phase error, and EVM plots for Walsh code 17 (figure 7).	[Trace/View] {I/Q Error} {Marker} {More} {Mkr → Despread}
Look at more power characteristics.	[Trace/View] {Code Domain}
Show I and Q symbol bits. The display bits are those of Walsh code 17.	{Demod Bits}
Inspect more data (figure 8). Up to 32 PGC's may be captured, and the bits of any serial combination of those may be viewed.	[Meas Setup] {More} {Capture Intvl} [10] [Return] [Restart] {Meas Interval} [3] [Enter] {Meas Offset} [5] [Enter]

Figure 7.
Magnitude error, phase error, and EVM plots

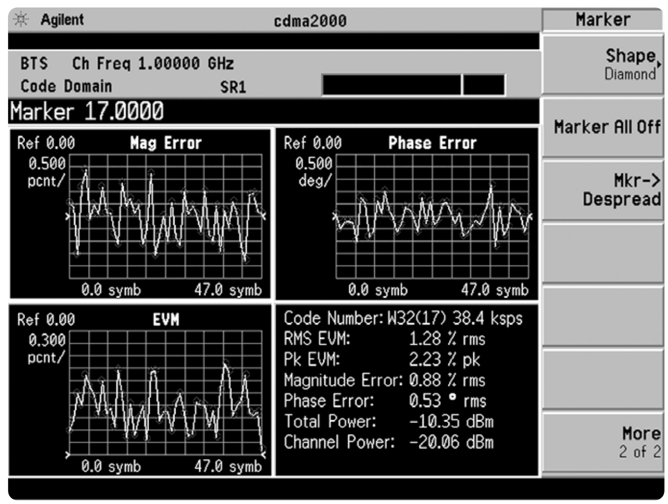
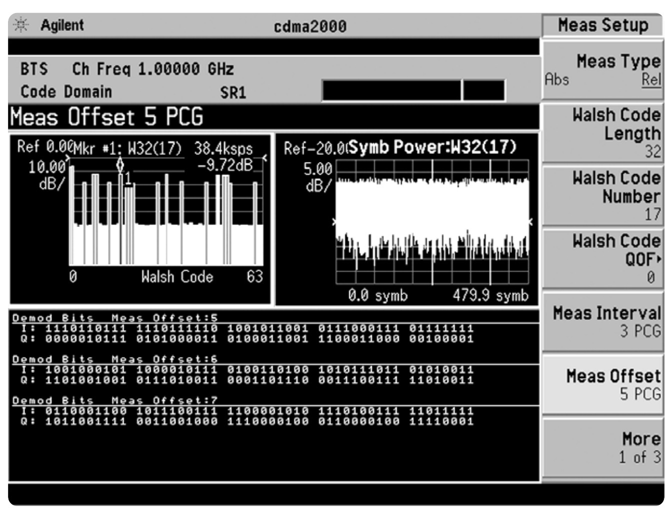


Figure 8.
Symbol power and demodulated I/Q bits

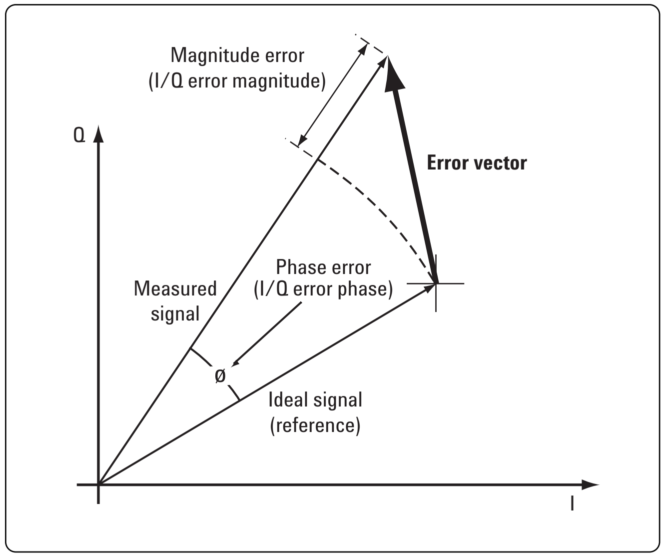


Part 7
Modulation accuracy (composite rho)

An important measure of modulation accuracy for cdma2000 signals 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. However, a rho measurement can also be performed on signals with multiple code channels. This measurement is known as composite rho. It allows you to verify the overall modulation accuracy for a transmitter, regardless of the channel configuration, as long as a pilot channel is present. 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.

Another effective way to quantify modulation accuracy also compares the received signal to an ideal signal. Figure 9 defines the error vector, a measure of the amplitude and phase differences between the ideal modulated signal and the actual modulated signal. The root-mean-square (rms) of the error vector is computed and expressed as a percentage of the square root of the mean power of the ideal signal. This is the error vector magnitude (EVM). EVM is a common modulation quality metric widely used in digital communications.

Figure 9.
The error vector



Composite EVM measures the EVM of the multi-code channel signal. It is valuable for evaluating the quality of the transmitter for a multichannel signal, detecting spreading or scrambling errors, identifying certain problems between baseband and RF sections, and analyzing errors that cause high interference in the signal.

The PSA measures rho and EVM, as well as magnitude, phase, and code domain errors. In this exercise, the above measurements will be explored.

Instructions	Keystrokes
On the PSA:	
Activate modulation accuracy measurement (figure 10). Observe the I/Q measured polar vector display on the right and the quantitative data provided on the left.	[MEASURE] {More} {Mod Accuracy}
Examine limit values menu. This menu allows the limits to be easily customized for use with the pass/fail indicator.	[Meas Setup] {Limits}
View magnitude and phase error and EVM plots (figure 11).	[Trace/View] {I/Q Error}
View power, timing, and phase data using the mulitchannel estimator (figure 12).	[Meas Setup] {More} {Advanced} (Multi Channel Estimator On} [Trace/View] {Power Timing & Phase}

Figure 10.
I/Q polar vector plot

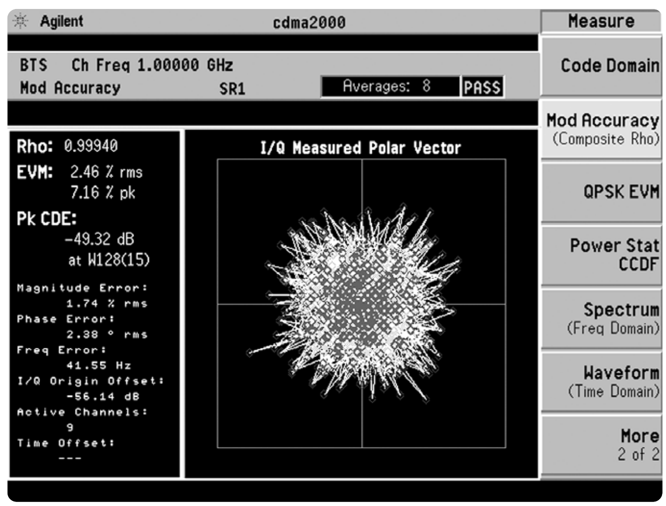


Figure 11.
I/Q error plots

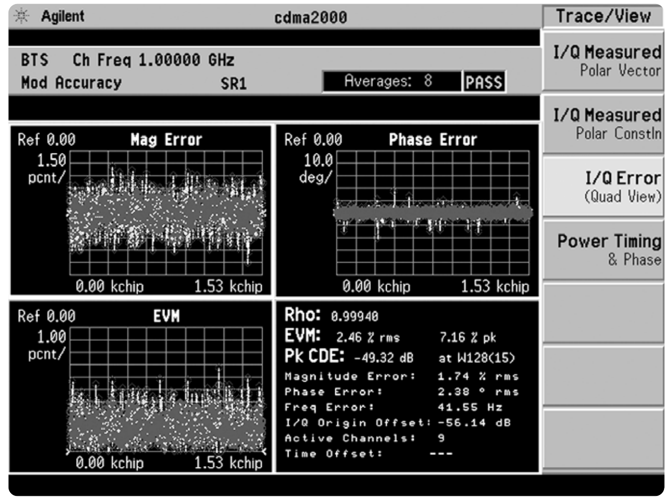
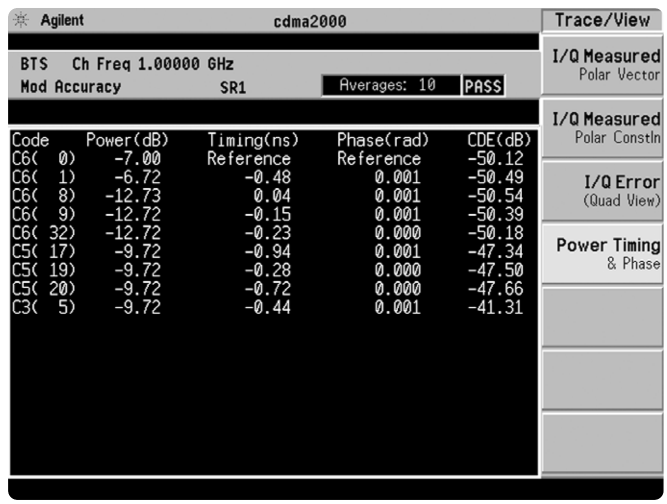


Figure 12.
Power, timing, and phase data



Part 8
QPSK EVM

The QPSK EVM measurement is used to get some indication of the modulation quality at the chip level for a single-channel signal. It can detect baseband filtering, modulation, and RF impairments, but does not detect spreading or scrambling errors.

This exercise involves changing the cdma2000 signal to a single-channel signal and measuring the error characteristics.

Instructions	Keystrokes
On the ESG:	
Change the signal to have one channel (pilot).	{CDMA2000 Select} {Pilot}
On the PSA:	
Switch on the QPSK EVM measurement (figure 13).	[MEASURE] {More} {QPSK EVM}
View magnitude and phase error and EVM plots (figure 14).	[Trace/View] {I/Q Error}

Figure 13.
QPSK constellation

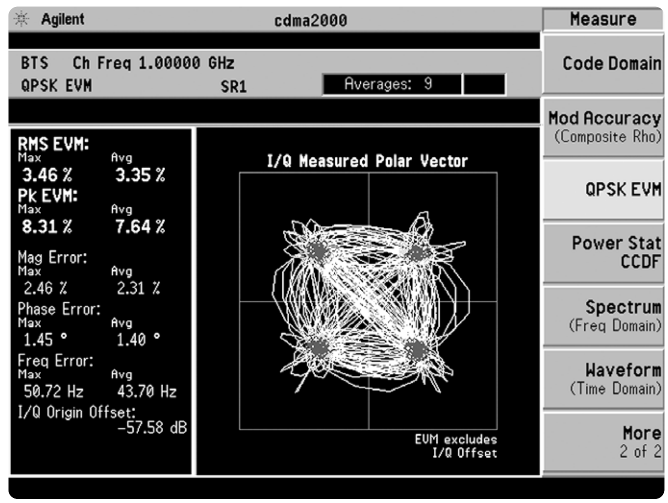
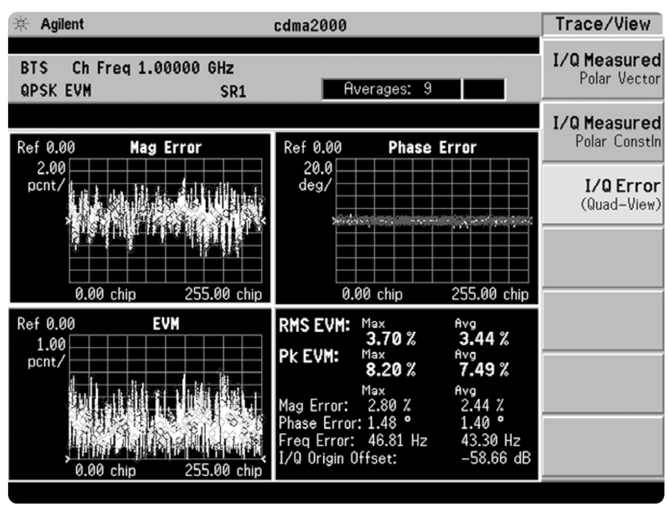


Figure 14.
Magnitude and phase error and EVM plots



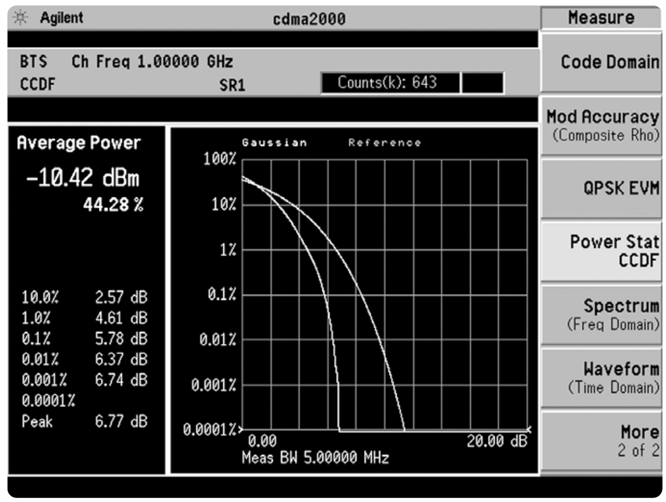
Part 9
Power statistics (CCDF)

The complementary cumulative distribution function (CCDF) is a plot of peak-to-average power ratio (PAR) versus probability and fully characterizes the power statistics of a signal. CCDF is a key tool for power amplifier design for cdma2000 base stations, which is particularly challenging because the amplifier must be capable of handling the high PAR the signal exhibits while maintaining good adjacent channel leakage performance. Designing multicarrier power amplifiers pushes complexity yet another step further.

This exercise illustrates the simplicity of measuring CCDF for cdma2000 transmitted signals.

Instructions	Keystrokes
On the PSA:	
Measure the CCDF (figure 15). The yellow line is the input signal. The blue reference line is the CCDF of Gaussian noise.	[MEASURE] {More} {Power Stat CCDF}

Figure 15.
CCDF



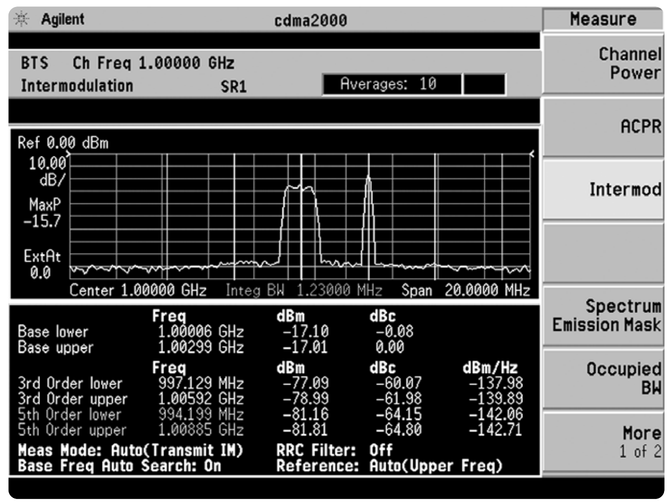
Part 10
Intermodulation distortion

This exercise requires two ESG vector signal generators, if available. The current ESG will be called ESG1 and should retain the current settings. The output of a second ESG, now called ESG2, should be added to that of ESG1 via a combiner.

This measurement measures the third and fifth harmonic distortion components of two continuous wave (CW) signals or of a cdma2000 modulated signal and a CW signal. The PSA makes this measurement quick and easy.

Instructions	Keystrokes
On the ESG2:	
Set up a CW signal, offset by 5 MHz from the W-CDMA signal of ESG1.	[Preset] [Frequency] [1.002] {GHz} [Amplitude] [-5] {dBm} [RF On]
On the PSA:	
Activate the intermodulation distortion measurement (figure 16).	[MEASURE] {Intermod}

Figure 16. Intermodulation distortion



Product literature

PSA Series - The Next Generation, brochure, literature number 5980-1283E
PSA Series, data sheet, literature number 5980-1284E
Phase Noise Measurement Personality, product overview, literature number 5988-3698EN
W-CDMA Measurement Personality, product overview, literature number 5988-2388EN
GSM with EDGE Measurement Personality, product overview, literature number 5988-2389EN
cdma2000 Measurement Personality, product overview, literature number 5988-3694EN
1xEV-DO Measurement Personality, product overview, literature number 5988-4828EN
cdmaOne Measurement Personality, product overview, literature number 5988-3695EN
NADC/PDC Measurement Personality, product overview, literature number 5988-3697EN
PSA Series Spectrum Analyzers, Option H70, 70 MHz IF Output, product overview, literature number 5988-5261EN
Self-Guided Demonstration for Spectrum Analysis, product note, literature number 5988-0735EN
Self-Guided Demonstration for Phase Noise Measurements, product note, literature number 5988-3704EN
Self-Guided Demonstration for W-CDMA Measurements, product note, literature number 5988-3699EN
Self-Guided Demonstration for GSM and EDGE Measurements, product note, literature number 5988-3700EN
Self-Guided Demonstration for cdma2000 Measurements, product note, literature number 5988-3701EN
Self-Guided Demonstration for 1xEV-DO Measurements, product note, literature number 5988–6208EN
Self-Guided Demonstration for cdmaOne Measurements, product note, literature number 5988-3702EN
Self-Guided Demonstration for NADC and PDC Measurements, product note, literature number 5988-3703EN
PSA Series Demonstration CD, literature number 5988-2390EN
Optimizing Dynamic Range for Distortion Measurements, product note, literature number 5980-3079EN
PSA Series Amplitude Accuracy, product note, literature number 5980-3080EN
PSA Series Swept and FFT Analysis, product note, literature number 5980-3081EN
PSA Series Measurement Innovations and Benefits, product note, literature number 5980-3082EN
PSA Series Spectrum Analyzer Performance Guide Using 89601A Vector Signal Analysis Software, product note, literature number 5988-5015EN
Selecting the Right Signal Analyzer for Your Needs, selection guide, literature number 5968-3413E
8 Hints for Millimeter Wave Spectrum Measurements, application note, literature number 5988–5680EN
PSA Series Spectrum Analyzer Performance Guide Using 89601A Vector Signal Analysis Software, product note, literature number 5988-5015EN
89600 series + PSA, 802.11A and HiperLAN2 ODFM Measurements, product note, literature number 5988-4094EN
N4256A Amplifier Distortion Test Set, product overview, 5988-2925EN
BenchLink Web Remote Control Softeware, product overview, literature number 5988-2610EN
HP 8566B/68B Programming Code Compatibility for PSA and ESA-E Series Spectrum Analyzers, product overview, literature number 5988-5808EN
IntuiLink Software, Data Sheet, Literature Number 5980-3115EN

For more information on the PSA series, please visit:

www.agilent.com/find/psa

Agilent Email Updates

www.agilent.com/find/emailupdates
Get the latest information on the products and applications you select.

Agilent Technologies' Test and Measurement Support, Services, and Assistance
Agilent Technologies aims to maximize the value you receive, while minimizing your risk and problems. We strive to ensure that you get the test and measurement capabilities you paid for and obtain the support you need. Our extensive support resources and services can help you choose the right Agilent products for your applications and apply them successfully. Every instrument and system we sell has a global warranty. Support is available for at least five years beyond the production life of the product. Two concepts underlie Agilent's overall support policy: "Our Promise" and "Your Advantage."

Our Promise
Our Promise means your Agilent test and measurement equipment will meet its advertised performance and functionality. When you are choosing new equipment, we will help you with product information, including realistic performance specifications and practical recommendations from experienced test engineers. When you use Agilent equipment, we can verify that it works properly, help with product operation, and provide basic measurement assistance for the use of specified capabilities, at no extra cost upon request. Many self-help tools are available.

Your Advantage
Your Advantage means that Agilent offers a wide range of additional expert test and measurement services, which you can purchase according to your unique technical and business needs. Solve problems efficiently and gain a competitive edge by contracting with us for calibration, extra-cost upgrades, out-of-warranty repairs, and on-site education and training, as well as design, system integration, project management, and other professional engineering services. Experienced Agilent engineers and technicians worldwide can help you maximize your productivity, optimize the return on investment of your Agilent instruments and systems, and obtain dependable measurement accuracy for the life of those products.

By internet, phone, or fax, get assistance with all your test and measurement needs.

Online assistance:

www.agilent.com/find/assist

Phone or Fax:
United States:
(tel) 1 800 452 4844

Canada:
(tel) 1 877 894 4414
(fax) (905) 282-6495

China:
(tel) 800 810 0189
(fax) 1 0800 650 0121

Europe:
(tel) (31 20) 547 2323
(fax) (31 20) 547 2390

Japan:
(tel) (81) 426 56 7832
(fax) (81) 426 56 7840

Korea:
(tel) (82 2) 2004 5004
(fax) (82 2) 2004 5115

Latin America:
(tel) (305) 269 7500
(fax) (305) 269 7599

Taiwan:
(tel) 080 004 7866
(fax) (886 2) 2545 6723

Other Asia Pacific Countries:
(tel) (65) 375 8100
(fax) (65) 836 0252
Email: asia@agilent.com

Printed in U.S.A., May 20, 2002
5988-3701EN

Agilent Technologies