

# Agilent PSA Series Spectrum Analyzers Self-Guided Demonstration for W-CDMA 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 W-CDMA measurement personality (Option BAF). Other portions of the self-guided demonstration are listed in the product literature section at the end of this guide and can 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.



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## 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 Technologies' 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 in order to perform this demonstration.

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 W-CDMA signal (Test Model 1).

Product type	Model number	Required options
ESG vector signal generator	E4438A	503, 504, or 506 – frequency range up to at least 3 GHz 001 or 002 – baseband generator 400 – 3GPP W-CDMA-FDD personalities
PSA series spectrum analyzer	E4440A/E4443A/E4445A/E4446A/E4448A	B7J – Digital demodulation hardware BAF – W-CDMA measurement personality

Instructions	Keystrokes
<b>On the ESG:</b>	
Set the carrier frequency to 2 GHz.	[Preset] [Frequency] [2] {GHz}
Set amplitude to -10 dBm.	[Amplitude] [-10] {dBm}
Select W-CDMA mode.	[Mode] {W-CDMA} {Arb W-CDMA}
Choose W-CDMA Test Model 1.	{W-CDMA Select} {Test Models} {Test Model 1 w/16 DPCH}
Turn on W-CDMA modulation.	{W-CDMA <u>On</u> }
Turn on RF output.	[RF <u>On</u> ]

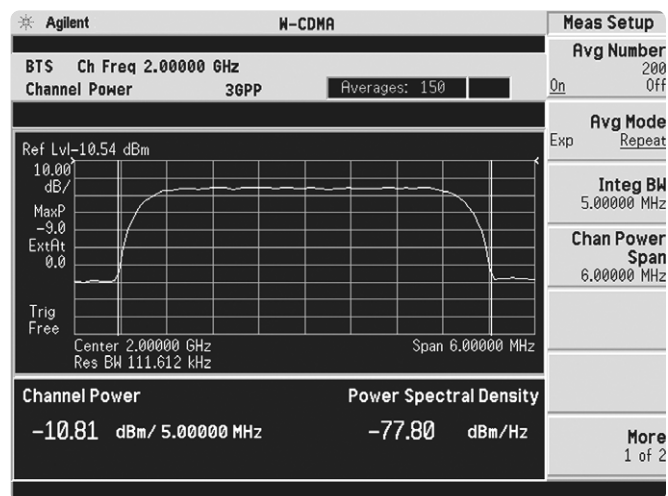
## Part 2 Channel power

The channel power measurement identifies the channel power within a specified bandwidth (default of 5 MHz, as per the Third-Generation Partnership Project (3GPP) W-CDMA technical specifications) and the power spectral density (PSD) in dBm/Hz.

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

Instructions	Keystrokes
<b>On the PSA:</b>	
Perform factory preset.	[System] {Power On/Preset} {Preset Type} {Factory}
Enter the W-CDMA mode in the analyzer. If {W-CDMA} does not appear in the Mode menu, try {More}.	[Preset] [Mode] {W-CDMA}
Set center frequency to 2 GHz.	[FREQUENCY] [2] {GHz}
Choose transmitter device.	[Mode Setup] {Radio} {Device <u>BTS</u> }
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)

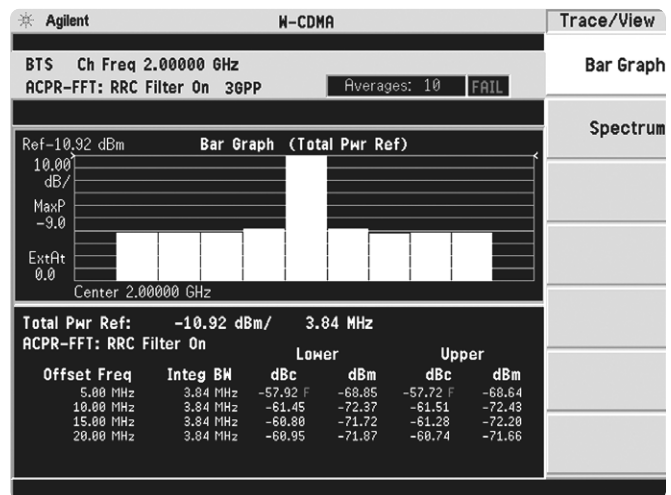
Reducing transmitter channel leakage allows for more channels to be transmitted simultaneously, which, in turn, increases base station efficiency. The ACPR, designated by the 3GPP W-CDMA specifications as the adjacent channel leakage power ratio (ACLR), is a measure of the power in adjacent channels relative to the transmitted power. The standard requires the power of both the transmitted and adjacent channels be measured through a root raised cosine filter (RRC) with a roll-off factor of 0.22.

The W-CDMA ACPR measurement performed in this exercise can measure up to five adjacent channel pairs with 3GPP compliance. The RRC filter defaults to “On” when the measurement is first activated, but may be disabled.

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

Instructions	Keystrokes
<b>On the PSA:</b>	
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]
Adjust the limit for one offset pair. 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} {Rel Lim (Car)} [-90] {dBc}
Add two more offsets.	{Offset} {C} {Offset Freq On} {Offset} {D} {Offset Freq On}
Return to bar graph view with table (figure 2). Observe the fail indicators in the table.	[Trace/View] {Bar Graph} [Zoom]

**Figure 2.**  
Multi-offset ACPR



## Part 4 Spectrum emission mask

The spectrum emission mask measurement required by 3GPP specifications encompasses different power limits and different measurement bandwidths (resolution bandwidths) at various frequency offsets. Figure 3 is a diagram of the specification requirements for power density versus frequency offset from carrier (excerpted from the 3GPP W-CDMA specifications document TS 25.104 v3.5.0). Completing the many measurements required to comply with this standard is made quick and easy with the PSA.

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. {Step Freq} and {Res BW} default to coupled mode. When these parameters are set manually, it is essential 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 {Res BW} 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}

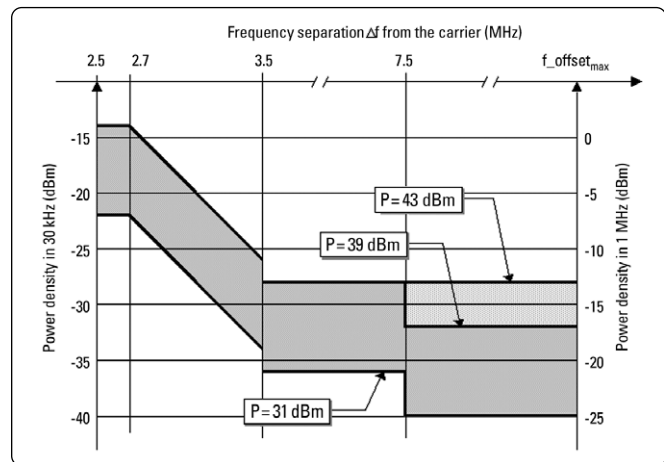
View customizable offsets and limits. Measurement parameters as well as limit values may be customized for any of the five offset pairs or for any individual offset.

[Meas Setup] {Offset/Limits} {More} {Limits}

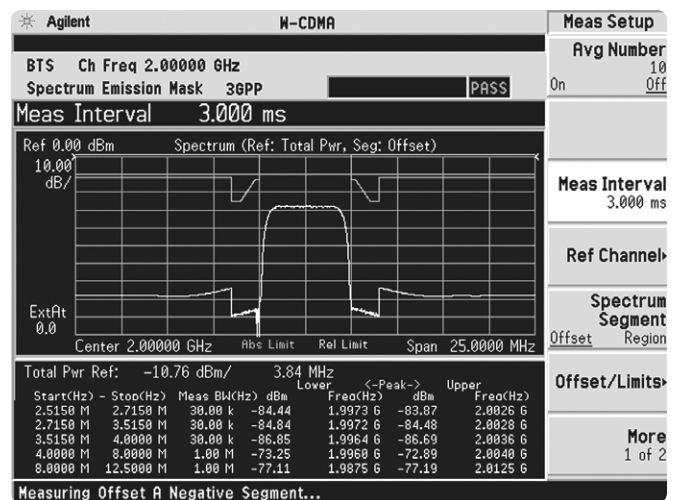
Specify measurement interval (up to 10 ms) and select detector type (average or peak) (figure 4).

[Meas Setup] {Meas Interval}, rotate KNOB, [↑] or [↓], {More}, toggle {Detector}

**Figure 3.**  
**3GPP W-CDMA**  
**specification for**  
**spectrum emission**  
**mask (from TS 25.104**  
**v3.5.0)**



**Figure 4.**  
**Spectrum**  
**emission mask**



## Part 5 Occupied bandwidth

The 3GPP specifications require the occupied bandwidth (OBW) of a transmitted W-CDMA signal to be less than 5 MHz, where occupied bandwidth is defined as the bandwidth containing 99 percent of the total channel 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 part of the span. The calculated difference is the occupied bandwidth. For simple setup, the PSA defaults to a 5-MHz PASS/FAIL limit value.

### Instructions

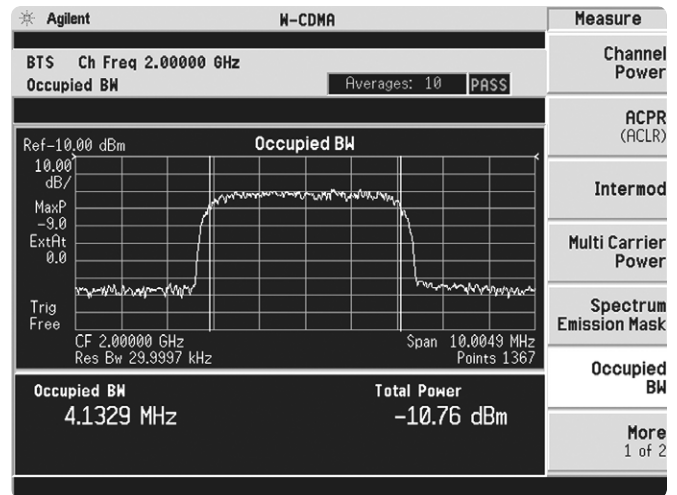
### Keystrokes

#### On the PSA:

Measure the occupied bandwidth (figure 5).

[MEASURE] {Occupied BW}

**Figure 5.**  
Occupied bandwidth



## Part 6 Code domain analysis

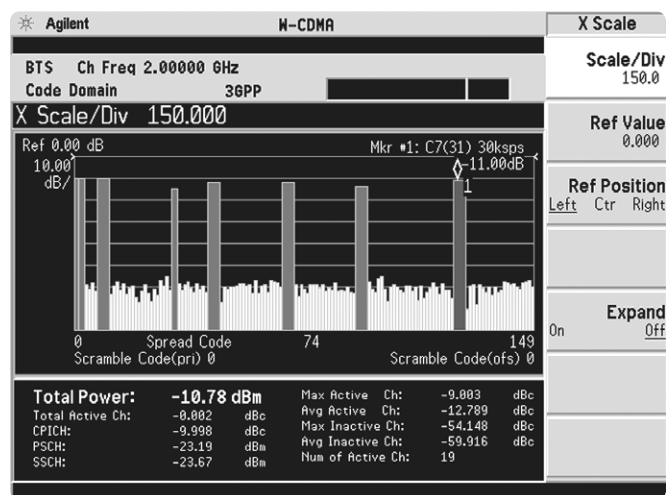
The code domain analysis measurement provides a variety of different results. First, code domain power analysis measures the distribution of signal power across the set of code channels, normalized to the total signal power. This measurement helps to verify that each code channel is operating at its proper level and helps to identify problems throughout the transmitter design from 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.

One complicated aspect of W-CDMA is that each of its different code channels may have a different spreading factor (SF) to accommodate different data rates. The challenge is to identify the active channels and the data rate of each. This PSA has the ability to identify active channels and measure and display both the code channel power and data 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.

Instructions	Keystrokes
<b>On the PSA:</b>	
Activate the code domain measurement. This measurement takes a few seconds while the PSA identifies the active channels.	[MEASURE] {More} {Code Domain}
Look at the power and rate of a specific channel. Notice that active channels are red and the width of a code channel is proportionate to the data rate of that channel.	[Marker] [125] [Enter]
Zoom (figure 6). This function allows close-up views of channel widths. Leave on widest span for the next step.	[Span], rotate KNOB

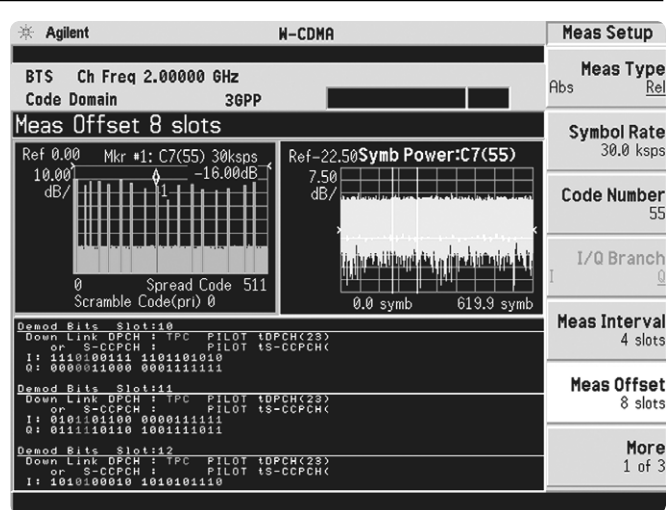
**Figure 6.**  
Code domain power



Instructions	Keystrokes
<b>On the PSA:</b>	
Run single measurement.	[Single]
Examine characteristics of the code channel with the active marker (125).	[Trace/View] {I/Q Error} [Marker] {More} {Mkr → Despread}
View symbol power and polar vector plots.	[Trace/View] {Code Domain}
Study a different channel.	[Marker] [220] [Enter] {More} {Mkr → Despread}
Show I and Q symbol bits.	[Trace/View] {Demod Bits}
Inspect more data (figure 7). Notice the indicated measurement interval change on the symbol power plot and the data change in the lower part of the display.	[Meas Setup] {Meas Interval}, rotate KNOB, [↑] or [↓], {Meas Offset}, rotate KNOB, [↑] or [↓]



**Figure 7.**  
Symbol power and demodulated I/Q bits



The PSA also offers flexibility features that enable you to customize measurements for your particular needs. Setting the capture interval determines the measurement time – short for fast measurements or long for in-depth analysis. Test models are pre-programmed into the PSA that allow you to disable the active channel identification functionality for fast mode capture intervals. Lastly, the analyzer may be programmed to synchronize from any W-CDMA code channel. The last part of this section explores some of these features.

**Instructions**

**Keystrokes**

**On the PSA:**

Return to the power graph. [Trace/View] {Power Graph & Metrics}

Set measure type to continuous. [Meas Control] {Measure Cont}

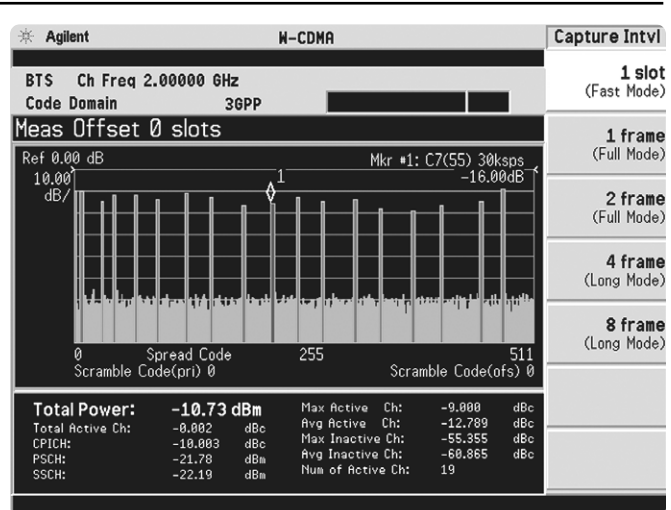
The default capture interval is for somewhat in-depth analysis. Observe the time it takes to make a measurement.

Change from active channel ID to measuring Test Model 1 with 16 DPCH. [Meas Setup] {More} {Symbol Boundary} {Pre-Defined Test Models} {Test Model 1 w/16 DPCH}

Set capture interval to fast mode (figure 8). {Capture Intvl} {1 slot}

Again observe the time to make a measurement; it has increased significantly.

**Figure 8.**  
Setting the capture interval



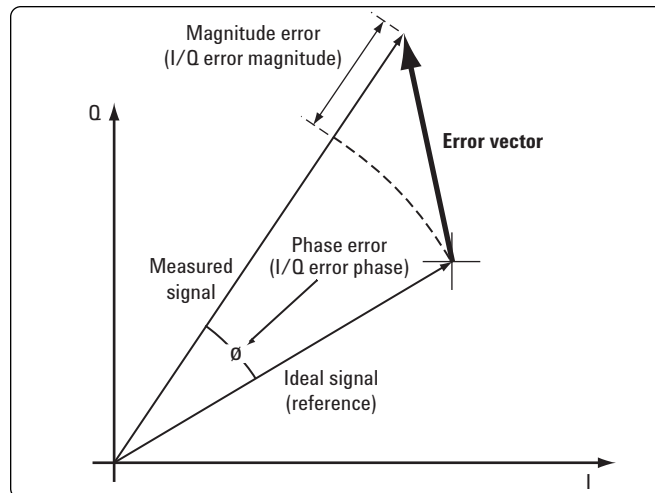
## Part 7 Modulation accuracy (composite EVM)

An effective way to quantify modulation accuracy is to compare the signal being measured 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.

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

In W-CDMA, specifically to address the possibility of uneven error power distribution, the composite EVM measurement is supplemented with another test called peak code domain error (CDE), which specifies a limit for the error power in any one code. To obtain this metric, the analyzer projects the error vector power on each code channel at a spreading factor of 256. The peak code domain power is then calculated from the code that returns the largest error power relative to the reference.

**Figure 9.**  
**The error vector**



CDMA-based formats, which rely on correlation as part of their operation, use another parameter called rho ( $\rho$ ). Rho is a measure 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 measured signal and the ideal reference. Rho is important because uncorrelated power appears as interference to a receiver.

The PSA can measure EVM, peak CDE, and rho for W-CDMA transmitter signals. The 3GPP specifications have requirements on both EVM and peak CDE. The PASS/FAIL limits default to these values. Additionally, the PSA permits synchronization from any W-CDMA code channel.

In this exercise, the above measurements will be performed.

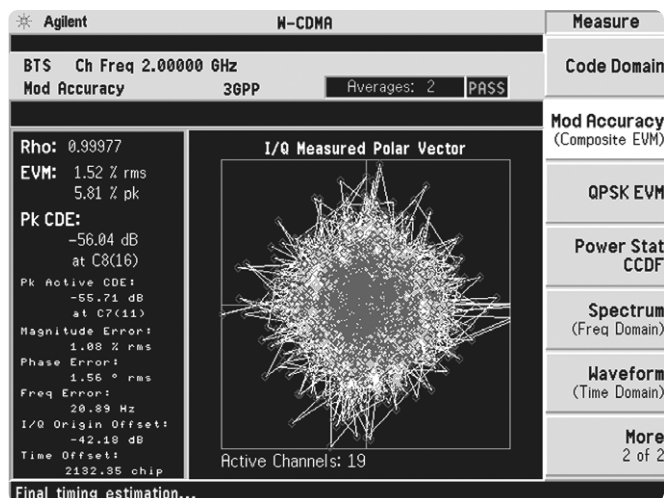
**Instructions**

**Keystrokes**

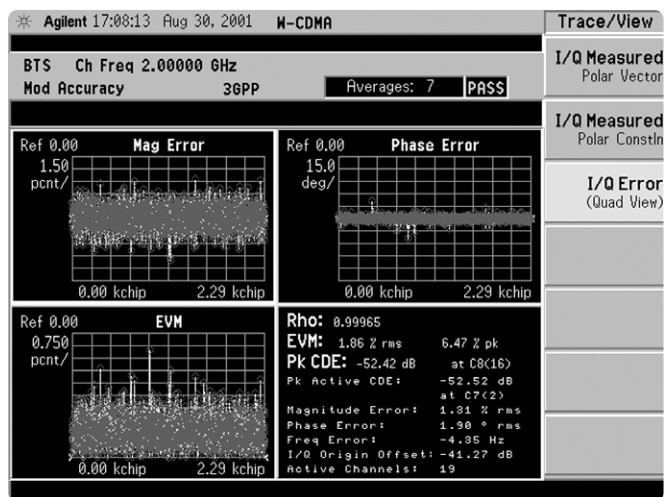
**On the PSA:**

- Activate modulation accuracy measurement [MEASURE] {More} {Mod Accuracy} (figure 10).
- Observe the I/Q measured polar vector display on the right and the quantitative data provided on the left.
- View magnitude and phase error and EVM plots. [Trace/View] {I/Q Error}

**Figure 10. Modulation accuracy**



**Figure 11. Error plots**



## 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 W-CDMA signal to a single-channel signal and measuring the error characteristics.

### Instructions

#### On the ESG:

Change the W-CDMA signal to 1 DPCH.

### Keystrokes

{W-CDMA Select} {1 DPCH}

#### On the PSA:

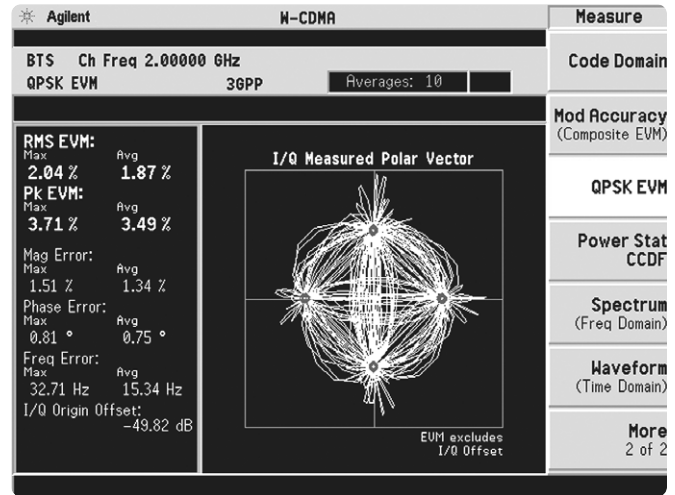
Switch on the QPSK EVM measurement (figure 12).

[MEASURE] {More} {QPSK EVM}

View magnitude and phase error and EVM plots.

[Trace/View] {I/Q Error}

**Figure 12.**  
QPSK EVM



## 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. It is a key tool for power amplifier design for W-CDMA 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 multi-carrier power amplifiers pushes complexity yet another step further.

This exercise illustrates the simplicity of measuring CCDF for W-CDMA.

### Instructions

#### On the PSA:

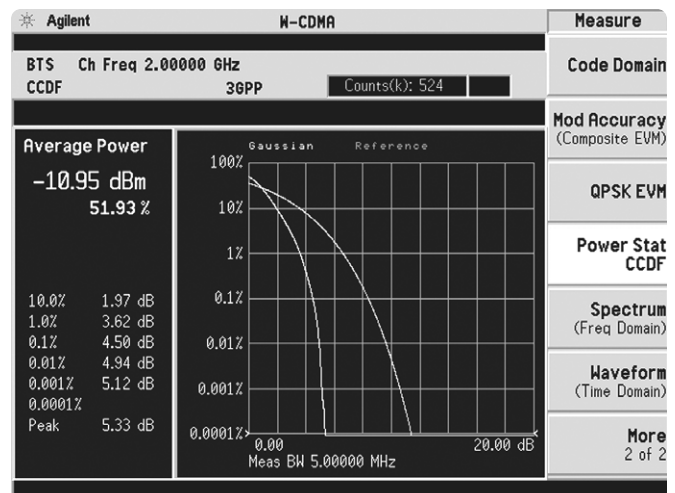
Measure the CCDF (figure 13).

### Keystrokes

[MEASURE] {More} {Power Stat CCDF}

The yellow line is the input signal. The blue reference line is the CCDF of Gaussian noise.

**Figure 13.**  
CCDF



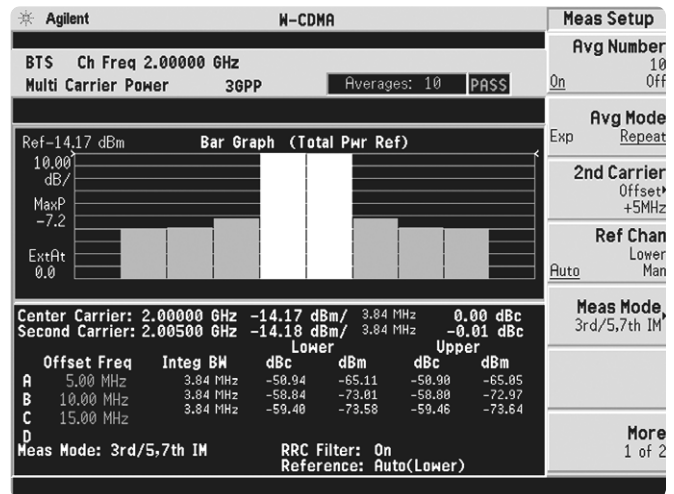
## Part 10 Multi-carrier power

Intermodulation distortion manifests itself as harmonic mixing products resulting from non-linear elements within power amplifiers. The 3GPP specification has strict requirements for multi-carrier intermodulation distortion at  $\pm 5$  MHz,  $\pm 10$  MHz, and  $\pm 15$  MHz offsets. The PSA series makes this measurement quickly and easily and provides results in an easy-to-read tabular format.

This section requires setting up the ESG to transmit a two-carrier signal to be measured with the PSA.

Instructions	Keystrokes
<b>On the ESG:</b>	
Turn off W-CDMA modulation.	{W-CDMA Off}
Turn on the multi-carrier function.	{Multicarrier On}
Change Freq Offset for rows 1 and 2 to -2.5 MHz and 2.5 MHz, respectively. This sets the carrier frequency separation to 5 MHz.	{Multicarrier Define}, use arrows to highlight desired item, {Edit Item}, key in desired value, {MHz}, repeat, {Apply Multicarrier}
Change the center frequency to 2.0025 GHz (this puts one carrier at 2 GHz and one at 2.005 GHz) and re-activate W-CDMA modulation.	[Return] {W-CDMA On} [Frequency] [2.0025] {GHz}
<b>On the PSA:</b>	
Enable the multi-carrier power measurement.	[MEASURE] {Multi Carrier Power}
Measure three offsets (figure 14).	{Meas Setup} {Meas Mode} {3rd/5, 7th IM}

**Figure 14.**  
Multi-carrier power







# 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 Software*, 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:

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