Agilent PSA Series Spectrum Analyzers Self-Guided Demonstration for Spectrum Analysis

Product Note

This demonstration guide will 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 spectrum analysis features, including the PowerSuite advanced power measurement capabilities. 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 of this demonstration may be performed using only the PSA. However, the E4438C ESG vector signal generator is highly recommended for completing part 6. It is also advised that Parts 1 and 2 be completed before exploring other sections of this demonstration because the results are used repeatedly throughout the remaining exercises. 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

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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 easy-to-use, 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
The basics: frequency, span, and amplitude

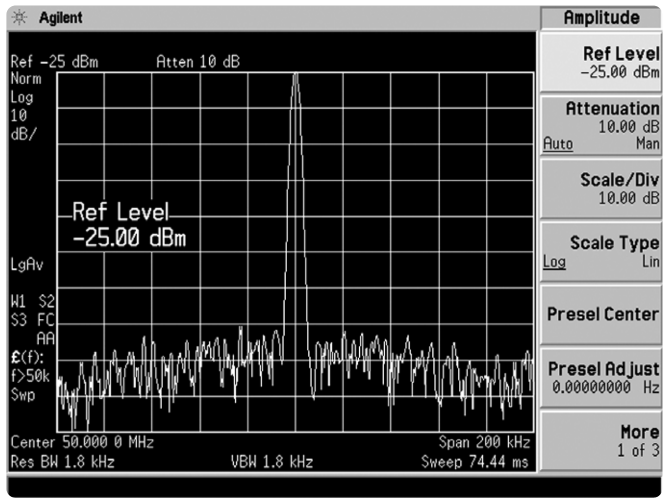
The fundamental parameters of spectrum analyzer measurements are frequency, span and amplitude. In a simple measurement, the signal of interest is tuned to the center of the display. The span and amplitude are set to optimize the view of that signal and its important characteristics.

The Agilent PSA series employs a simple and intuitive user interface that enables you to make these measurements quickly and easily. In addition, the display is bright and colorful, lists the measurement settings, and may be expanded for optimal viewing.

In this section, the 50 MHz internal reference signal is enabled, and the basic measurements are performed.

Instructions	Keystrokes
Perform factory preset.	[System] {Power On/Preset} {Preset Type} {Factory}
Turn on internal 50 MHz reference signal.	[Preset] [Input/Output] {Input Port} {Amptd Ref}
Tune the center frequency to 50 MHz.	[FREQUENCY] [50] {MHz}
Adjust span to 200 kHz.	[SPAN] [200] {kHz}
Set reference level so that signal peak is at the top graticule line (figure 1).	[AMPLITUDE], rotate KNOB, [⇑] or [⇓]
Expand the display. (Press [ESC] to return.)	[Display] {Full Screen}

Figure 1. 50 MHz internal reference



Part 2
Save and recall

The PSA series has several easy-to-use options for data storage and file transfer. Save states, traces and screen captures on the internal hard drive, on a floppy disk, or directly to a PC via GPIB or LAN. Each file can be assigned an alphanumeric filename and is stored complete with size, time, and date stamping.

In this section, the instrument state is saved and recalled using the file system.

Instructions	Keystrokes
Save the instrument state using the file system:	
1. Call up the file save menu.	[File] {Save}
2. Specify STATE as the type of file to save.	{Type} {State}
3. Enter the filename DEMO using alpha editor.	{Name}, enter the filename DEMO using alphabet keys, [Enter]
4. Choose internal memory drive.	{Dir Select}, highlight -C- with KNOB or [⇓], {Dir Select}
5. Save into internal memory.	{Save Now}
Recall (load) the instrument state DEMO.	[Preset] [File] {Load}, highlight filename DEMO with KNOB or [⇓], {Load Now}

Part 3
Resolving low-level signals

Resolution bandwidth, input attenuation, and video averaging

The ability of an analyzer to measure low-level signals is affected by its internally generated distortion, its noise floor or sensitivity, and the measurement setup. The Agilent PSA series provides the flexibility to fine-tune your measurement setup for dynamic range optimization.

The resolution bandwidth filter determines the resolution at which signals are viewed. A sufficiently narrow resolution bandwidth will reveal low-level signals that are otherwise disguised by the presence of larger signals or by the noise floor. Reducing the resolution bandwidth increases dynamic range, and the trade-off for resolution is speed.

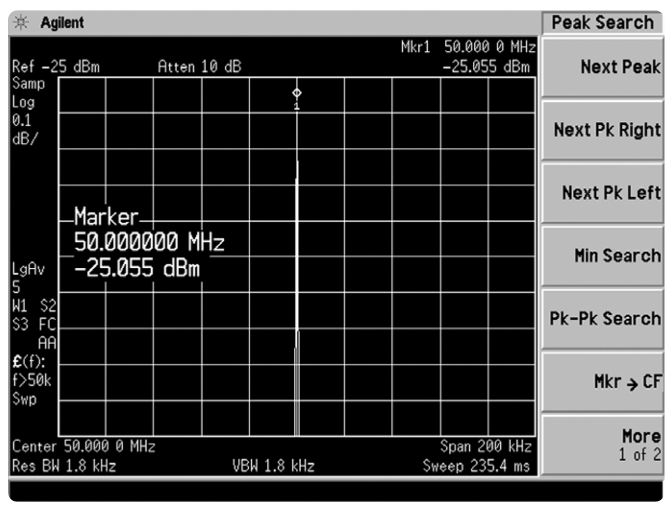
The step attenuator permits you to variably limit the amplitude of signals being passed into the analyzer. As with the resolution bandwidth, reducing the input attenuation increases dynamic range. The PSA series provides an attenuator that steps in 2 dB increments for unparalleled flexibility of dynamic range.

Video bandwidth and video averaging can also be used to identify low-level signals. The video bandwidth function changes the bandwidth of the analyzer's post-detection (video) low-pass filter. This filter reduces variations in the trace values or "smoothes" the trace. Video averaging simply averages the traces as each sweep is made.

In this section, the 50-MHz internal reference signal is employed to explore dynamic range settings.

Instructions	Keystrokes
Recall (load) the instrument state DEMO (if not already loaded).	[Preset] [File] {Load}, highlight filename DEMO with KNOB or [⇓], {Load Now}
Adjust resolution bandwidth. Notice that as the resolution bandwidth is decreased, the displayed noise level also decreases, but sweep time is increased.	[BW/Avg] {Resolution BW}, rotate KNOB, [⇑], or [⇓]
Adjust the input attenuation. The input attenuator steps in 2 dB increments.	[AMPLITUDE] {Attenuation}, rotate KNOB, [⇑], or [⇓]
Reduce the video bandwidth.	[BW/Avg] {Video BW} [⇓]
Return to default settings. A # appears next to settings that are not auto coupled.	[Auto Couple] {Auto All}
Zoom in on the signal peak.	[AMPLITUDE] {Ref Level} [-25] {dBm} {Scale/Div} [0.1] {dB}
Stabilize measurement using averaging. View available types of averaging.	[BW/Avg] {Average On} [5] [Enter] {Avg/VBW Type} [Return]
Do a peak search to display third decimal place accuracy (figure 2).	[Peak Search]

Figure 2. Measurement accuracy



Part 4
Dealing with random noise

Detector sampling, marker noise function, and internal preamplifier (Option 1DS)

Modern spectrum analyzers use digital technology for data acquisition and manipulation. The PSA series digitizes the IF signal immediately following the resolution bandwidth filter, and all data is handled digitally from this point forward in the system. Thus, the analyzer offers advanced features for optimizing measurements, which becomes especially useful when dealing with random noise.

The input voltage signal being measured is divided into bins and several samples are taken from each bin (figure 3). To extract the useful data, one point from each bin must be selected for display on the screen. The display detector determines this point and you can define the detector mode. The peak detector selects the highest sample value in the bin. This is best for measuring continuous wave signals where capturing the peak value is important. When measuring noise, however, using the peak detector will add a bias, and thus the sample detector is more appropriate; it selects the final bin value for display. The negative peak detector selects the lowest sample value in the bin. Another type of detector, called the normal detector in the PSA series, uses a combination of the above detectors to accurately represent continuous wave signals and noise in the same trace.

Based on the measurement setup, the PSA will default to the appropriate detector mode, but this setting may be customized if desired. In this section, some of the different detector modes will be compared and contrasted using the analyzer's trace saving capabilities.

Instructions	Keystrokes
Recall (load) the instrument state DEMO.	[Preset] [File] {Load}, highlight filename DEMO with KNOB or [⇩], {Load Now}
Set new span.	[SPAN] [100] {MHz}
Set Trace 1 to peak detection mode. Note that the View command freezes the screen trace and the Clear Write command restarts the measurement trace.	[Det/Demod] {Detector} {Peak} [Trace/View] {Trace} (press {Trace} until 1 is underlined) {View} {Trace} (press {Trace} until 2 is underlined) {Clear Write}
Set Trace 2 to negative peak detection mode. Note that the Clear Write command restarts the measurement trace. Notice the effective noise floor drop.	[Det/Demod] {Detector} {Negative Peak} [Trace/View] {View} {Trace} (press {Trace} until 3 is underlined) {Clear Write}
Set Trace 3 to sample detection mode (figure 4).	[Det/Demod] {Detector} {Sample}

Figure 3. Detection in signal bins

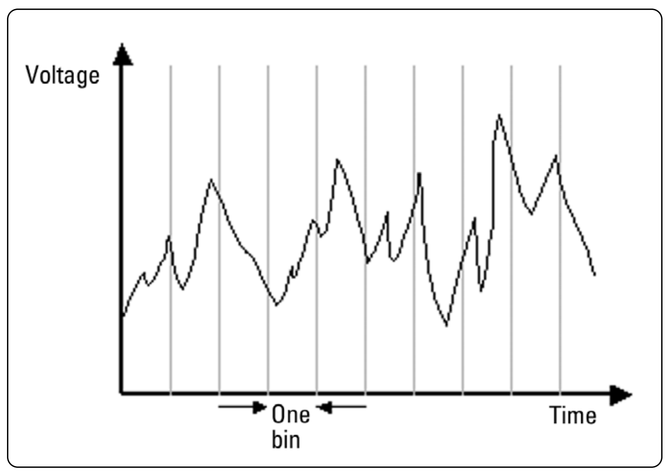
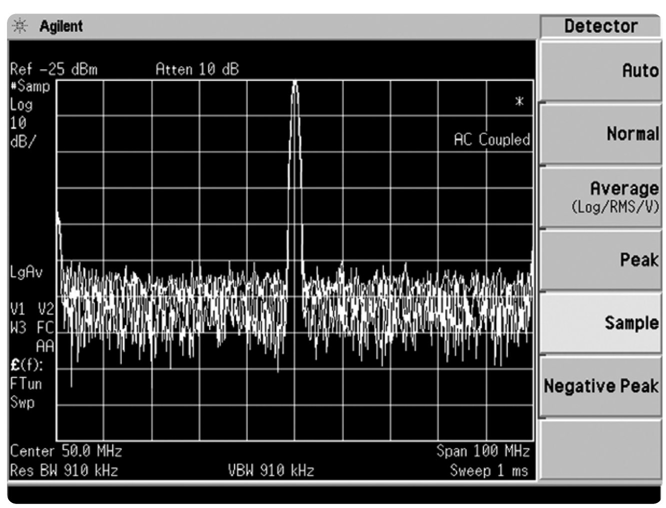


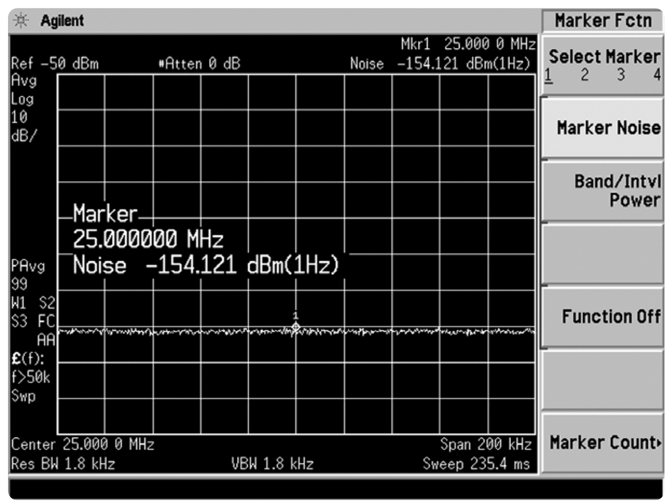
Figure 4. Detector modes



The marker noise function accurately calculates the average noise level at the marker position, referenced to a 1 Hz noise power bandwidth. It is a very useful tool for making quick and accurate noise measurements. The optional internal preamplifier (Option 1DS) allows the measurement of very low signal levels. The preamplifier amplifies the input signal to raise it above the analyzer's noise level, allowing better viewing of low-level signals. In this exercise, you can see how the preamplifier lowers the effective noise level.

Instructions	Keystrokes
Set the center frequency, span, amplitude, and attenuation level.	[Preset] [FREQUENCY] [25] {MHz} [SPAN] [200] {kHz} [AMPLITUDE] {Ref Level} [-50] {dBm} {Attenuation} [0] {dB}
Smooth out the noise floor with averaging.	[BW/Avg] {Average On}
Measure noise floor using Marker Noise (figure 5). This is the analyzer's displayed average noise level (DANL). Note this value. Note: The following step is only for those systems containing the optional internal preamplifier (Option 1DS).	[Marker Fctn] {Marker Noise}
Enable the internal preamplifier. Compare this value with the previously noted value.	[AMPLITUDE] {More} {Int Preamp On} [Marker]

Figure 5.
Maker noise function



Part 5
Optimizing measurements

Phase noise optimization

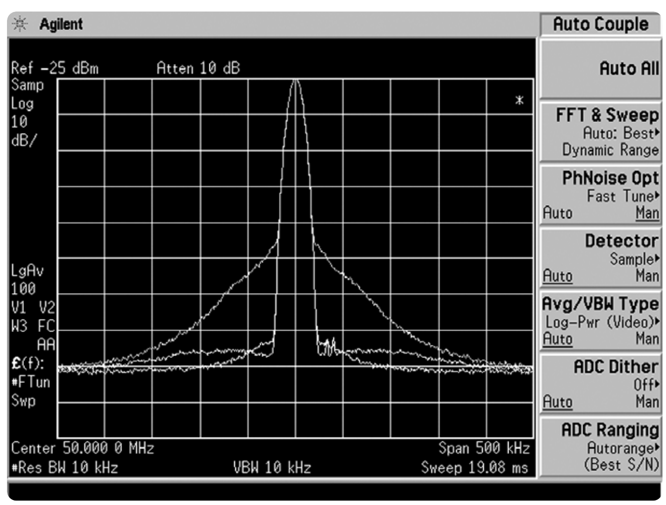
A pure sine wave carrier has an infinitely thin spectral line in the frequency domain. Realistically, a carrier will have imperfections in the form of phase noise. Phase noise appears as a skirt at the base of a carrier and may obscure a low-level signal that is close in frequency to this carrier. The local oscillator (LO) sweep of a spectrum analyzer may add phase noise when measuring a carrier, which degrades dynamic range for close-in measurements.

The PSA series of spectrum analyzers offers phase noise optimization to reduce phase noise around a carrier and increase dynamic range. There are three modes of operation for phase noise optimization. For very wide spans, where phase noise is not a factor, the LO is optimized for fast tuning. Measuring in spans where phase noise is a consideration, the analyzer can optimize the LO for low phase noise greater than 50 kHz from the carrier or for low phase noise less than 50 kHz from the carrier. The PSA will automatically determine the appropriate phase noise optimization based on the span and RBW settings you have specified. For greater user control, the phase noise optimization may also be set manually.

In this exercise, the manual phase noise optimization settings will be explored to demonstrate the analyzer's capabilities.

Instructions	Keystrokes
Recall (load) the instrument state DEMO.	[Preset] [File] {Load}, highlight filename DEMO with KNOB or [⇓], {Load Now}
Set new span and and resolution bandwidth.	[SPAN] [500] {kHz} [BW/Avg] {Res BW} [10] {kHz}
Turn on averaging. Observe "£ (f): f > 50k" at the left of the display; this indicates phase noise optimization for greater than 50 kHz.	{Average <u>On</u>}
Save this to the screen as Trace 1.	[Trace/View] {Trace} (press {Trace} until 1 is underlined) {View} {Trace} (press {Trace} until 2 is underlined) {Clear Write}
Change phase noise optimization to optimize for less than 50 kHz. Observe the drop in noise level close in to the carrier.	[Auto Couple] {PhNoise Opt} {Optimize £(f) for f < 50 kHz }
Save this trace to the screen as Trace 2.	[Trace/View] {View} {Trace} (press {Trace} until 3 is underlined) {Clear Write}
Change phase noise optimization to optimize for fast tuning (figure 6). Notice the dramatic increase in the phase noise close in to the carrier, but all traces meet at the edges of the display. This illustrates that optimizing the LO for fast tuning is appropriate for making measurements in wide spans.	[Auto Couple] {PhNoise Opt} {Optimize LO for Fast Tuning}

Figure 6.
Phase noise optimization modes



FFT versus swept

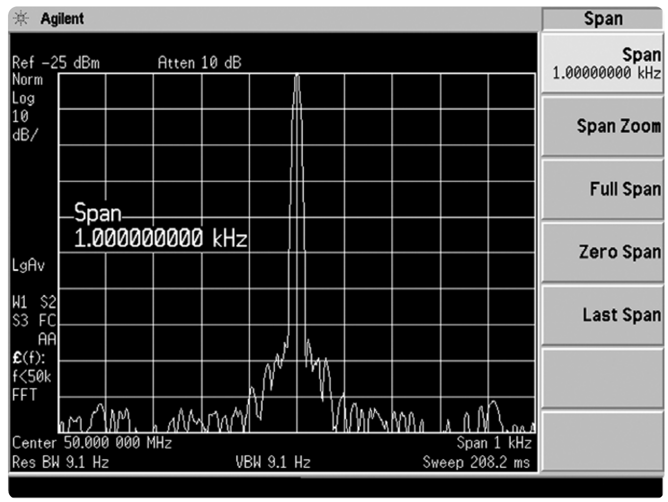
There are two common types of spectrum analyzers, the swept-tuned analyzer and the FFT analyzer. The swept-tuned analyzer measures the power at each frequency as it passes through the resolution bandwidth filter. This type of analyzer is especially useful for making spectrum measurements with wide filter settings because results are obtained accurately and quickly. The FFT analyzer digitizes the time-domain voltage waveform and then performs a FFT to obtain the frequency spectrum. This type of analyzer is desirable for very narrow spans with narrow resolution bandwidths because it can reduce measurement “sweep” time.

The PSA series can perform either as a swept-tuned analyzer or as a FFT analyzer, and it offers two levels of control. For the most control over specific measurements, you may choose either FFT or swept mode. Otherwise, you may choose to optimize for speed or dynamic range and opt to have the analyzer determine the appropriate mode. The instrument’s default is to optimize for dynamic range.

This exercise examines the FFT and swept mode selections.

Instructions	Keystrokes
Recall (load) the instrument state DEMO. Observe “Swp” on the left margin of the display; this indicates the analyzer is operating in swept mode. Also note the sweep time provided in the lower right corner of the display.	[Preset] [File] {Load}, highlight filename DEMO with KNOB or [⇓], {Load Now}
Change the span to 1 kHz (figure 7). The left margin now says “FFT” indicating the analyzer has automatically switched to FFT mode. Make a note of the sweep time (lower right corner).	[SPAN] [1] {kHz}
Manually change the operating mode to sweep. Notice the dramatic increase in the sweep time.	[Auto Couple] {FFT & Sweep} {Manual: Swept}

Figure 7.
FFT mode operation



Part 6
PowerSuite: comprehensive power measurements

The PSA series spectrum analyzers offer easy-to-use one-button RF power measurements with format-based setups.

Measurements:
- channel power
- occupied bandwidth
- adjacent channel power (ACP)
- multi-carrier power
- power statistics (complementary cumulative distribution function (CCDF))
- harmonic distortion
- burst power
- third-order intercept (TOI)
- spurious emissions
- spectrum emission mask

Formats:
- cdmaOne (IS-95)
- cdmaOne (J-STD-008)
- NADC
- GSM/EDGE
- W-CDMA (3GPP)
- cdma2000 (SR1)
- cdma2000 (SR3-MC)
- cdma2000 (SR3-DS)
- PDC
- Bluetooth™

The first part of this exercise describes the setup of an Agilent ESG vector signal generator to provide a single-carrier W-CDMA signal. Then the PSA will be used to make ACP and CCDF measurements.

Instructions	Keystrokes
Signal generator setup	
Note: This section describes the setup to provide a W-CDMA signal using the Agilent ESG vector signal generator. (Option 503, 504 or 506; Option 001 or 002; and Option 400 required.)	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.
Set frequency and power level.	[Preset] [Frequency] [2] {GHz} [Amplitude] [-10] {dBm}
Enable W-CDMA signal.	[Mode] {W-CDMA} {Arb W-CDMA} {W-CDMA On} [RF On]
Spectrum analyzer setup	
Preset the analyzer and set the center frequency to 2 GHz.	[Preset] [FREQUENCY] [2] {GHz}
Select W-CDMA format. Use {More} to view available formats.	[Mode Setup] {Radio Std} {3GPP W-CDMA}
Choose ACP measurement. Use {More} to view available one-button measurements.	[MEASURE] {ACP} [Trace/View] {Combined}
Optimize the reference level. With this feature, the analyzer automatically determines the appropriate reference and attenuation levels for the best dynamic range.	[Meas Setup] {Optimize Ref Level}
Activate the noise-near-noise correction. This algorithm takes a few seconds to complete, but the advantage is that it adds 2-3 dB of dynamic range.*	{More} {Noise Corr On}
Set up and turn on limits (figure 8). In this exercise, limits are set up to fail and thus illustrate the color change in the pass/fail indicators.	{More} {Offset/Limits} {Pos Offset Limit} [-80] {dB} [Return] {More} {Limit Test On}
Now make a CCDF measurement (figure 9).	[MEASURE] {Power Stat CCDF}

*May not be apparent if source is limiting factor of dynamic range.

Figure 8.
W-CDMA
ACP measurement

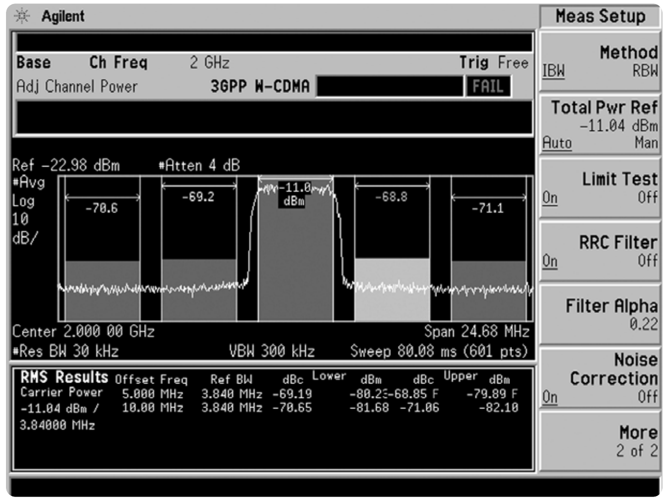
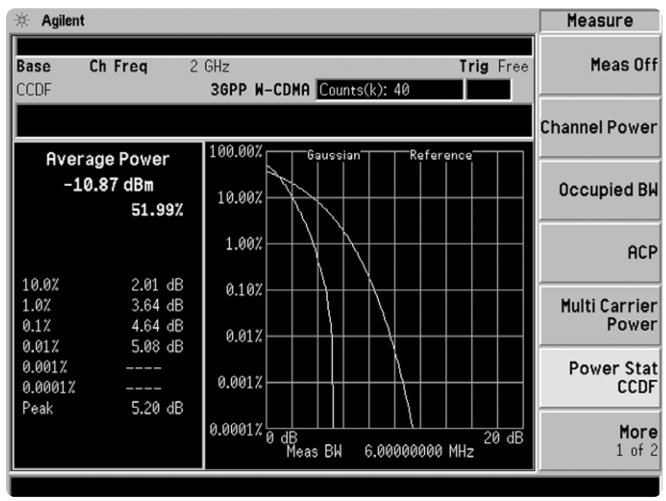


Figure 9.
W-CDMA
CCDF measurement

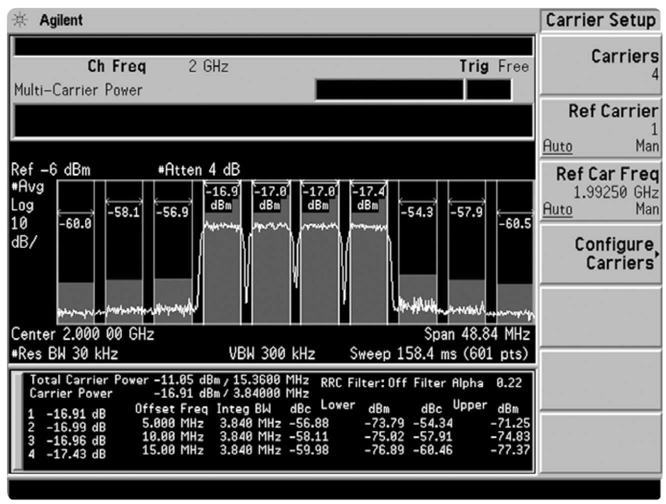


The last part of this exercise involves making power measurements on a four-carrier W-CDMA signal. First the ESG is configured, and then the measurement is made with the PSA.

After completing this exercise, explore some of the other PowerSuite measurements and formats for a more thorough understanding of its capabilities.

Instructions	Keystrokes
Signal generator setup	
Set up a 4-carrier W-CDMA signal.	{W-CDMA Off} {Multicarrier On} {W-CDMA Select} {4 Carriers} {W-CDMA On}
Spectrum analyzer setup	
Select the multi-carrier power measurement.	[MEASURE] {Multi Carrier Power} [Trace/View] {Combined}
Explore the settings (figure 10). Notice that reference level optimization, noise correction, and limits are available in this measurement. There are also additional settings for carrier setup.	[Meas Setup] {Carrier Setup} [Return] {More}

Figure 10. W-CDMA muliti-carrier power measurement



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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
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IntuiLink Software, Data Sheet, Literature Number 5980-3115EN

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