# Agilent
# PSA Series Spectrum Analyzers
# Self-Guided Demonstration
# for Phase Noise 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 phase noise measurements provided by the PSA's optional Phase Noise Measurement Personality (Option 226). 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 ESG vector signal generator and PSA with the Phase Noise Measurement Personality. 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 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

Begin by connecting the 50 Ω RF output of the ESG vector signal generator to the 50 Ω RF input of the PSA series spectrum analyzer with a 50 Ω RF cable. Turn on the power in both instruments.

This exercise demonstrates how to set up the ESG to provide a RF test signal.

If you do not have an ESG available, you can turn on the PSA's internal RF reference signal (50 MHz) to run the following demonstration. Since the PSA's center frequency defaults to 50 MHz, you do not need to change the center frequency of the PSA as shown in Part 2.

| Product type | Model number | Required options |
|---|---|---|
| ESG vector signal generator | E4438C | |
| PSA series spectrum analyzer | E4440A/E4443A/E4445A/ E4446A/E4448A | 226 – phase noise measurement personality |

| Instructions | Keystrokes |
|---|---|
| **On the ESG:** | |
| Set carrier frequency to 1 GHz. | [Preset] [Frequency] [1] {GHz} |
| Set amplitude to 0 dBm. | [Amplitude] [0] {dBm} |
| Turn on RF output. | [RF On/Off] |

| Instructions | Keystrokes |
|---|---|
| Turn on the PSA's internal 50 MHz RF reference signal. | [Preset] [Mode] {Phase Noise} [Input/Output] {Input/Output} {Input Port} {Amptd Ref} |

## Part 2
## Phase noise log plot

Log plot measures single-sideband phase noise (in dBc/Hz) versus offset frequencies expressed in logarithmic scale. This allows you to view the phase noise behavior of the signal under test across decades of offset frequencies. The PSA with the phase noise personality can display up to six decades of offset frequencies simultaneously.

This exercise demonstrates the one-button phase noise log plot measurement.

| Instructions | Keystrokes |
|---|---|
| Enter phase noise measurement mode in the analyzer. | [Preset] [Mode] {Phase Noise} |
| Set center frequency to 1 GHz. | [FREQUENCY] [1] {GHz} |
| Activate log plot measurement. Observe the phase noise curve in a default setting. | [MEASURE] {Log Plot} |
| Examine settings (figure 1). Use this step to make setup changes in any measurement. | {Meas Setup} |

**Figure 1. Phase noise log plot**
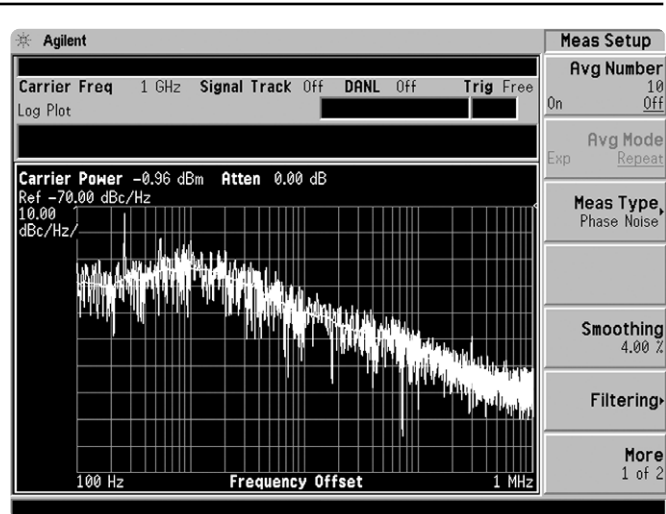
The following exercises demonstrate the PSA's flexibility that enables you to optimize your phase noise measurements.

**Note:**
Averaging and video filtering are part of the measurement. Therefore, every time you change the number of averages and/or level of video filtering, you need restart the measurement to obtain the results. Smoothing, on the other hand, is a post-processing operation on the stored data. You can observe the smoothed results while you are changing the length of smoothing segment. Implementations of video filtering and smoothing are fast, whereas averaging takes longer.

**Span and amplitude**

| Instructions | Keystrokes |
|---|---|
| **Specify the span of offset frequencies:** | |
| Set start offset frequency to 100 Hz. | [SPAN] {Start Offset} [100] {Hz} |
| Set stop offset frequency to 100 MHz. | {Stop Offset} [100] {MHz} |
| **Specify amplitude scale:** | |
| Set reference value to -85 dBc/Hz. | [AMPLITUDE] {Ref Value} [-85] {dBc/Hz} |
| Set scale per division to 7 dB. | {Scale/Div} [7] {dB} |
| Restart the measurement. | [Restart] |

**Averaging, video filtering and smoothing**

| Instructions | Keystrokes |
|---|---|
| Activate averaging and set average number to 5. | [Meas Setup] {Avg Number} until "On" is underlined, then [5] [Enter] |
| Restart the measurement (figure 2). Observe convergence of the raw data trace. | [Restart] |
| Disable averaging. | Press {Avg Number} until "Off" is underlined |
| Activate video filtering and set filtering level to "Maximum". | {Filtering} {Maximum} |
| Restart the measurement. Observe the filtering result (figure 3). | [Restart] |
| View smoothed data trace with raw or averaged trace turned off. | [Trace/View], press {Trace} until "1" is underlined, {Blank} |
| Adjust length of smoothing segment. Observe the displayed traces with different smoothing segments (figure 4). | [Meas Setup] {Smoothing}, then press [⇓] or [⇑], or rotate the knob |

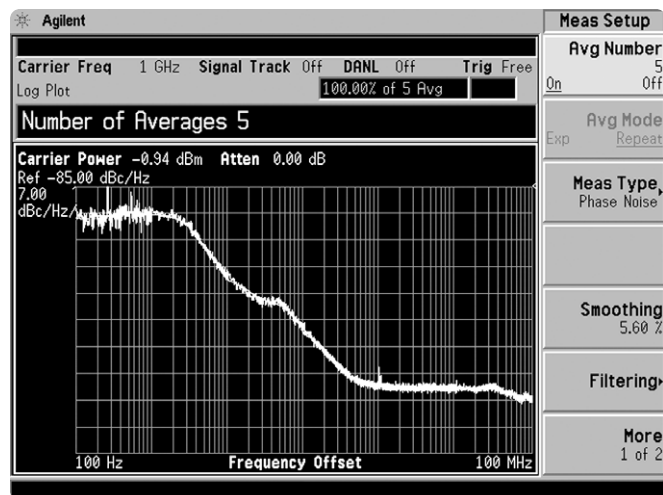**Figure 2.
Phase noise plot
with averaging**

**Figure 3.**
**Phase noise plot**
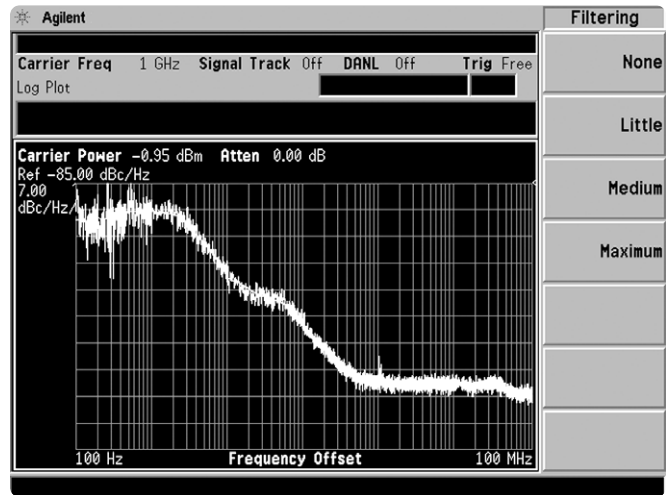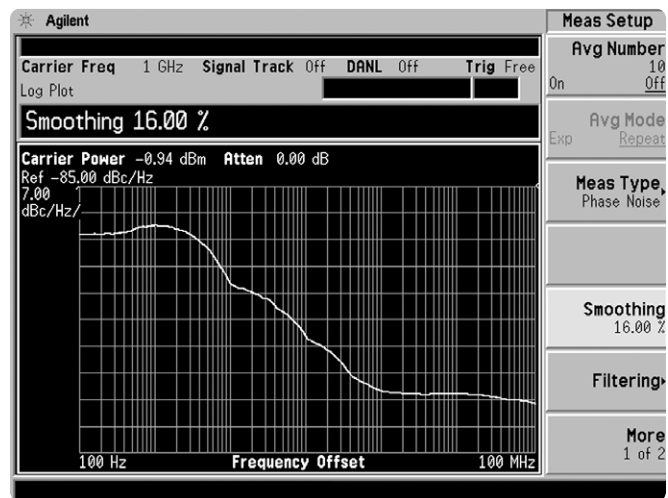**with video filtering**



**Figure 4.**
**Smoothed**
**phase noise plot**

## Part 3
## Spot frequency phase noise

If you are interested in phase noise versus time at a single offset frequency, use the spot frequency phase noise measurement. This measurement lets you monitor phase noise behavior at the user-specified single offset frequency in real time. Meanwhile, you can also check carrier frequency drifting to evaluate the stability of a carrier signal.

In this exercise, you will measure the spot frequency at 20 kHz and explore the signal tracking and the carrier frequency drifting features.

| Instructions | Keystrokes |
| --- | --- |
| Activate the spot frequency measurement. | [MEASURE] {Spot Frequency} |
| Specify the spot frequency to 20 kHz. | [Meas Setup] {Spot Offset} [20] {kHz} |
| Adjust amplitude scale to optimize the display. Observe the real-time phase noise display at 20 kHz offset frequency (figure 5). | [Amplitude] {Phase Noise} {Ref Value} [-110] {dBc/Hz} {Scale/Div} [0.5] {dB}, then rotate the knob for fine adjustment with either {Ref Value} or {Scale/Div} pressed |
| View spot frequency phase noise with a table of numerical readouts. | [Trace/View] {Numerical} |
| Return to graphical view. | {Graphical} |
| Turn on signal tracking to check carrier frequency Drift. Check the carrier frequency drifting at a fixed time interval, for example at each 10 percent of one sweeping cycle. | [Frequency], toggle {Signal Track} to "On" {Tracking} {Mode} {Interval} {Interval} [10] {Enter} |
| Adjust amplitude scale of frequency drifting (or Delta Frequency). Observe the spot frequency phase noise with carrier drifting plot (figure 6). | [Amplitude] {Delta Freq}, {Scale/Div}, then rotate the knob to an optimized display |
| Check the frequency stability of the carrier signal when the carrier drifting goes beyond the specified tolerance. This example uses a ±1 dBc/Hz tolerance level. | [Frequency], toggle {Signal Track} to "On", {Tracking} {Mode} {Tolerance} {Tolerance +/-} [1] {dBc/Hz} |
| Set amplitude scale of frequency drifting (or delta frequency) to 1 kHz/Div. | [Amplitude] {Delta Freq} {Scale/Div} [1] {kHz} |
| Check frequency drifting at the "Delta Freq" panel while manually adjusting the ESG RF output frequency by ±2 kHz increments. | Set ESG: [Frequency], then rotate the knob clock- or counterclock-wise around the previously specified center frequency |

**Figure 5.**
**Spot frequency**
**phase noise**
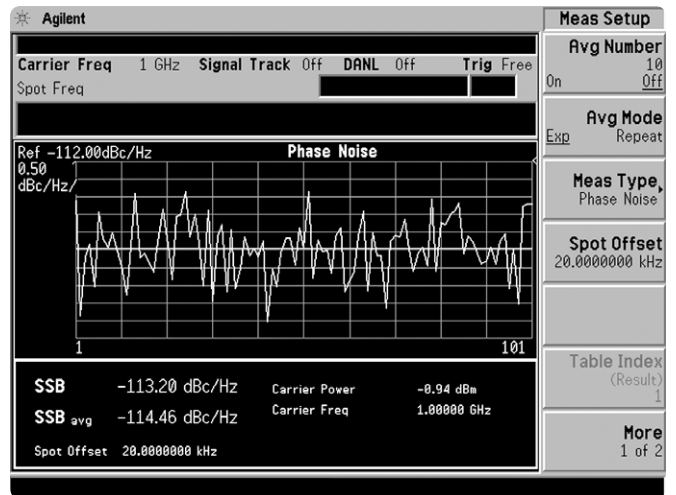


**Figure 6.**
**Phase noise with**
**carrier drifting**
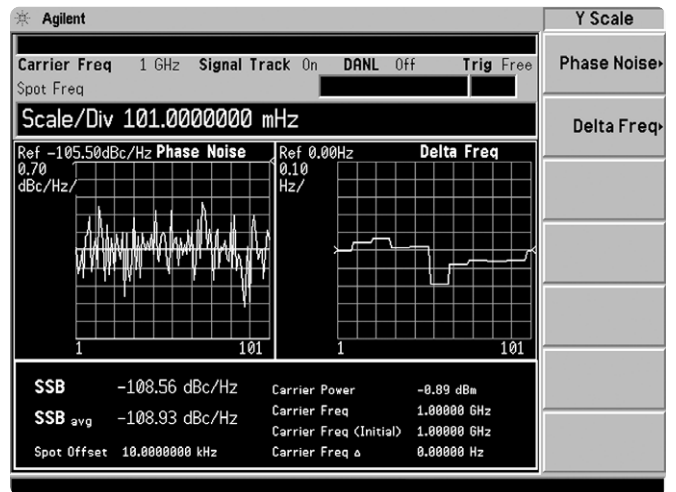
## Part 4
## Displayed average noise level (DANL) measurements

The DANL floor of a spectrum analyzer sets limitations for measuring the smallest input signal, usually at the far-out offset frequencies. When the amplitude of a signal under test is getting closer to the DANL floor, a significant measurement error can occur, which makes the measurement no longer valid. To help you ensure the measurement is valid, the PSA with the phase noise measurement personality measures the DANL floor and displays it along with the phase noise plot. It also automatically optimizes the PSA input attenuation level for the far-out offset frequency to lower the DANL floor for a better measurement sensitivity.

The following exercise demonstrates the DANL measurements, display, and optimization.

| Instructions | Keystrokes |
|---|---|
| Re-enter phase noise measurement mode in the analyzer. | [Preset] [Mode] {Phase Noise} |
| Set center frequency to 1 GHz. | [FREQUENCY] [1] {GHz} |
| Activate log plot measurement. | [MEASURE] {Log Plot} |
| Adjust the X-scale. | [SPAN] {Start Offset} [1] {kHz} {Stop Offset} [100] {MHz} |
| Adjust the Y-scale. | [AMPLITUDE] {Ref Value} [-85] {dBc/Hz} |
| View the smoothed phase noise plot without raw data. | [Trace/View], toggle {Trace} to underline "1", {Blank} |
| Transfer the smoothed phase noise curve from "Trace 2" to "Trace 3". | Toggle {Trace} to underline "2", {More 1 of 2} {Operations} {2 → 1} |
| Activate the DANL measurement. Note the stepped DANL floor that results from the DANL optimization (figure 7, lower trace). | [Meas Setup] {Meas Type} {DANL Floor} [Restart] |



**Figure 7.**
**DANL floor displayed with a smoothed phase noise plot**
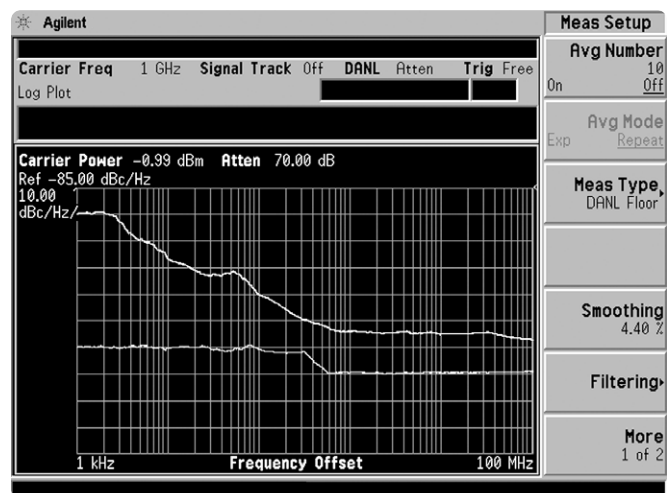
There are two ways to measure the DANL floor. One way is to remove the signal from the PSA and terminate the RF input of the PSA with a 50-Ω termination. The other way is to suppress the input signal to a negligible level at the input mixer by increasing the input attenuation to 70 dB. While the measurement personality defaults to the latter, you can also choose to physically remove the signal from the PSA RF input and terminate it as follows.

| Instructions | Keystrokes |
|---|---|
| Set DANL measurement method as "Removal". | [Input/Output], toggle {DANL Method} to underline "Removal" |
| Activate the DANL measurement. | [Restart], then you will see an instruction panel, follow the instructions to remove the signal from PSA input and to connect a 50-Ω termination at the RF input. Press [ESC] to continue. |

## Part 5
## Integrated noise

Different applications require different measures for evaluating phase noise behaviors. In the digital world, root-mean-square (rms) phase deviation/jitter (in degrees or radians) and rms phase jitter (in seconds) are used more frequently to evaluate the stability of a high-frequency clock. On the other hand, the residual FM is more important to amplifier designers and manufacturers. With the phase noise plot obtained from Part 4, these measures can be calculated by positioning a pair of markers to specify the interval of integration.

| Instructions | Keystrokes |
|---|---|
| Clear the DANL floor from the results obtained in Part 4. | [Trace/View], toggle {Trace} to underline "2", {Blank} |
| Set the starting point of the integration interval to 10 kHz.<br>Notice a marker labeled "1" shows up on the phase noise plot at 10 kHz offset frequency. | [Marker] {More}, toggle {Marker Trace} until "1" is underlined, {More} {Normal} [10] {kHz} |
| Activate the rms phase deviation (in degrees) measurement.<br>Notice a marker labeled "1R" superimposed on the marker labeled "1". | {RMS Noise} {RMS Noise Degree} |
| Set the ending point of the integration interval to 1 MHz.<br>The rms phase deviation/jitter in degrees between 10 kHz and 1 MHz is shown in the top right corner of the display (figure 8). | [1] {MHz} |
| Change the rms phase deviation/jitter into radians.<br>Notice the readout in the top right corner changes to radians. | {RMS Noise Radian} |
| Change the rms phase jitter into seconds.<br>Notice the readout in the top right corner changes to seconds. | {RMS Noise Jitter} |
| For residual FM, set the integration interval starting from 30 kHz. Notice a marker labeled "1" shows up on the phase noise plot at 30 kHz offset frequency. | [Marker] {Normal} [30] {kHz} |
| Activate the residual FM measurement, and set the integration interval ending at 1 MHz. The top right corner of the display shows the integration interval and the residual FM in Hz (figure 9). | {Residual FM} [1] {MHz} |

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**Figure 8.**
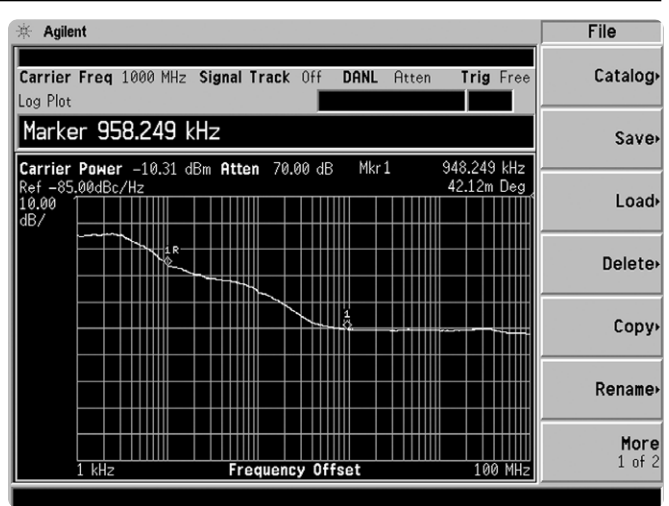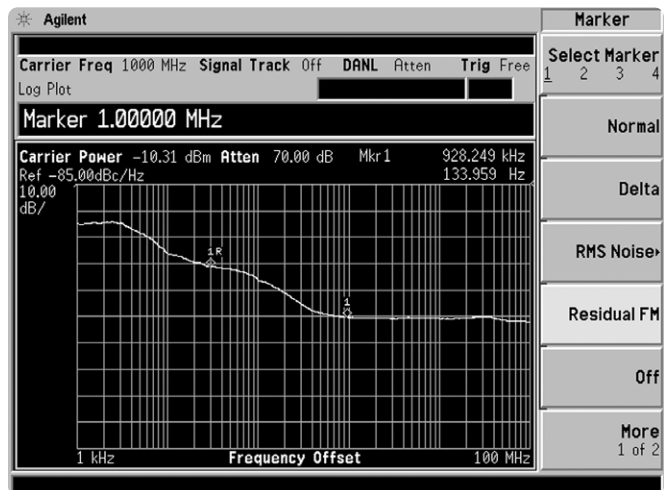**RMS phase**
**deviation in degrees**



**Figure 9.**
**Residual FM**

# 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 Softeare,* 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

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