

Agilent PSA Series Spectrum Analyzers Phase Noise Measurement Personality

Technical Overview with Self-Guided Demonstration
Option 226

The PSA Series is Agilent Technologies' highest performing spectrum analyzer family. In addition to offering advanced and comprehensive RF and microwave measurement capability, you can add the phase noise measurement personality (Option 226) to transform the PSA into a one-button phase noise tester. Whether you're in R&D or manufacturing, the PSA's phase noise personality provides a comprehensive measurement solution to characterize the phase noise behavior of your systems and components easily, quickly, and accurately.



Phase Noise



Agilent Technologies

Phase Noise Measurements Made Easier, Faster, and More Accurate

High-purity, high-stability signals have become more important to the modern communications, aerospace, and defense industries. Phase noise is one of the most crucial measures to evaluate the short-term stability of a signal. Therefore, an accurate, fast, and easy-to-use phase noise measurement tool is critical in the R&D and manufacturing environments.

In addition to its superior combination of speed, accuracy, flexibility, and dynamic range, the Agilent PSA Series offers a Phase Noise Measurement Personality - providing an ideal tool for design verification and troubleshooting, as well as production-line testing. By adding this measurement personality, you integrate a phase noise tester and a high-performance spectrum analyzer into one box.

- Expand design possibilities with powerful measurement capability and flexibility.
- Expedite troubleshooting and design verification with an intuitive user interface and numerous features.
- Streamline manufacturing with speed, reliability, and ease of use.
- Maximize yields with accurate measurements and operator independent results.

This technical overview includes

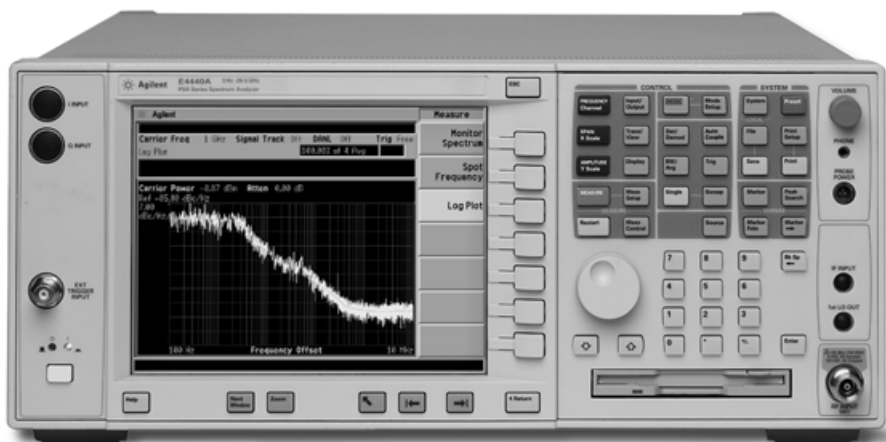
- measurement details
- demonstrations
- PSA Series key specifications
- ordering information
- related literature

All demonstrations utilize the PSA Series and 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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Spot frequency
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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 next section.

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
If no source is available:	
Turn on the PSA's internal 50 MHz RF reference signal.	[Preset] [Mode] {Phase Noise} [Input/Output] {Input/Output} {Input Port} {Amptd Ref}

Phase noise log plot

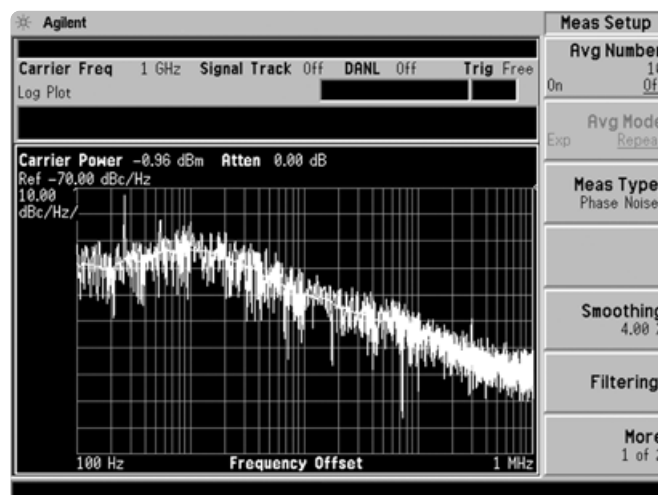
Log plot measures single-sideband phase noise (in dBc/Hz) versus offset frequencies expressed in logarithmic scale. This allows you to view the phase noise behavior of the signal under test across decades of offset frequencies.

- View entire phase noise behavior across a wide range of offset frequencies (10 Hz to 100 MHz).
- Simultaneously display up to seven decades of offset frequency in logarithmic scale.
- Measure phase noise with a user-specified number of averages.
- Perform trace smoothing with user-adjustable smoothing segment length.
- Utilize a suite of comprehensive PSA marker functions.
- Search carrier frequency automatically.
- Apply multilevel video filtering.
- Make single and continuous measurements.

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.	[MEASURE] {Log Plot}
Observe the phase noise curve in a default setting.	
Examine settings (Figure 1).	{Meas Setup}
Use this step to make setup changes in any measurement.	

Figure 1.
Phase noise log plot



These 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 to 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

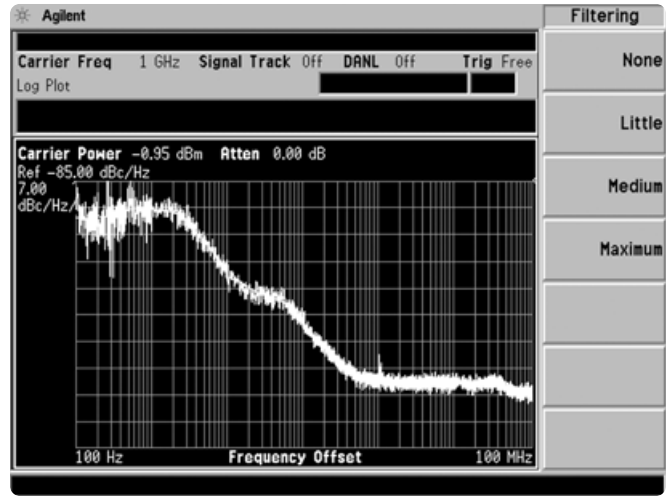
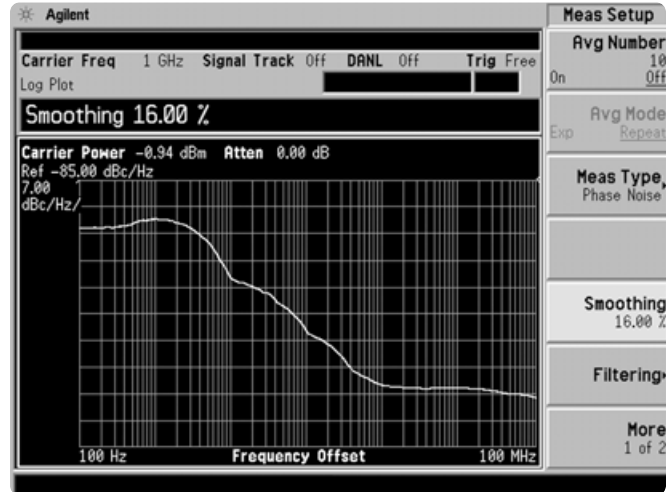


Figure 4.
Smoothed
phase noise plot



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.

- Monitor phase noise fluctuation versus time at a user-specified single offset frequency (between 100 Hz and 100 MHz).
- Use the PSA's phase noise optimization feature to minimize the analyzer's internal phase noise.
- Check carrier frequency drifting with carrier signal tracking.
- Search carrier frequency automatically.
- View results in graphic and numeric list formats.

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 \pm } [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

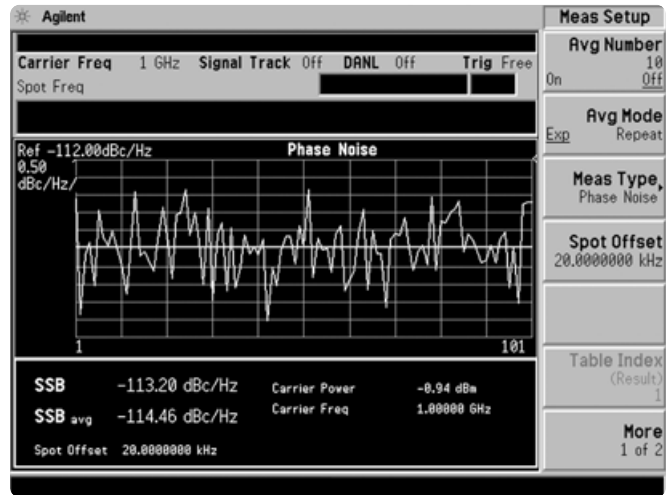
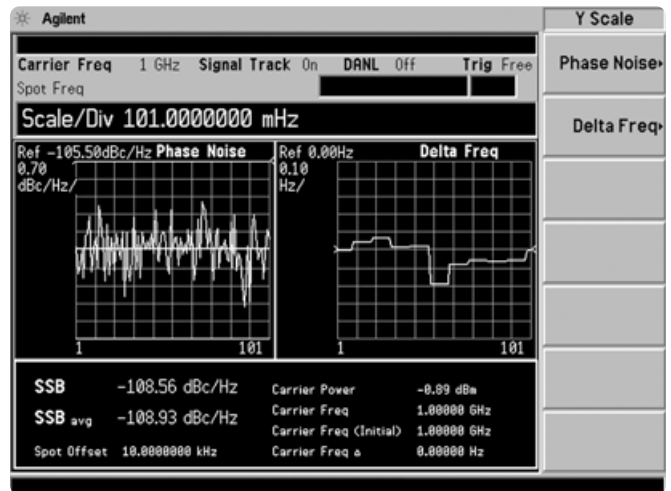


Figure 6.
Phase noise with
carrier drifting



Displayed average noise level (DANL) measurements

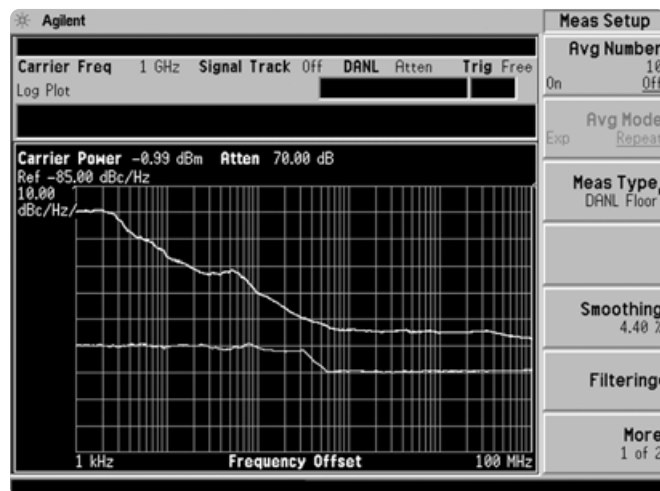
The DANL floor of a spectrum analyzer sets limitations for measuring the smallest input signal, usually at the far-out offset frequencies. When the amplitude of a signal under test is getting closer to the DANL floor, a significant measurement error can occur, which makes the measurement no longer valid. 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.

- Measure and reference the DANL of the PSA to the carrier amplitude.
- Display the DANL floor together with the log plot phase noise.
- Store and record traces easily.

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.

Phase noise cancellation

The PSA also feature phase noise cancellation. Using a source with low phase noise, you can eliminate the influence of the PSA's internal phase noise on measurement results for close-in offset frequencies.

- Improve measurement accuracy and sensitivity.
- Make the best trade-off between cancellation effectiveness and computation time with user-selectable thresholds.

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 PSA, these measures can be calculated by positioning a pair of markers to specify the interval of integration.

- Characterize phase noise related behaviors from different angles for various applications.
- Adjust integration bandwidth by positioning a pair of markers on the log plot.
- Calculate rms phase deviation/jitter in degrees or radians.
- Calculate rms phase jitter in seconds.
- Calculate the residual FM in Hz.
- View numeric marker readings for calculated results.

With the phase noise plot obtained in the previous demonstration, use the markers to make the integrated noise measurements.

Instructions	Keystrokes
Clear the DANL floor from the results obtained in the previous demonstration.	[Trace/View], toggle {Trace} to underline "2", {Blank}
Set the starting point of the integration interval to 10 kHz. 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. 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. 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. Notice the readout in the top right corner changes to radians.	{RMS Noise Radian}
Change the rms phase jitter into seconds. 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}

Figure 8.
RMS phase
deviation in degrees

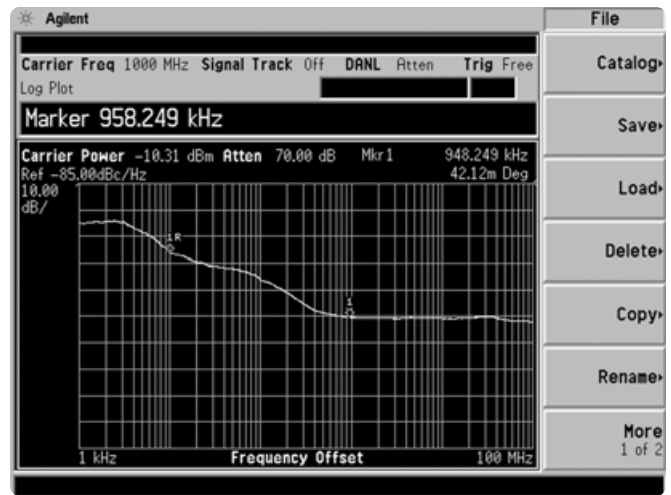
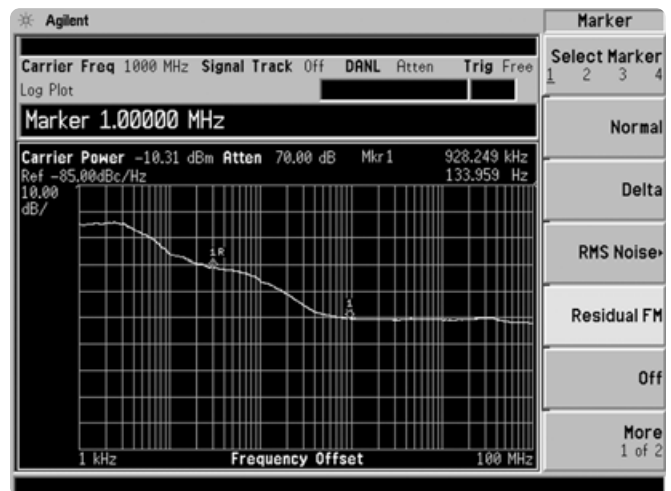


Figure 9.
Residual FM



PSA Series Key Specifications¹

Phase noise measurement personality

Measurement modes	Spectrum monitor Log plot Spot frequency
Offset frequency range	
Minimum offset frequency	10 Hz
Maximum offset frequency	
Spot frequency measurement	100 MHz
Log plot measurement	Up to 10 GHz
Maximum number of decades	7
Maximum input signal level	+20 dBm
Minimum input signal level (for optimum dynamic range)	-50 dBm
Measurement accuracy (nominal)	
Amplitude accuracy	±0.29 dB (RSS of error sources, each of which is warranted, not including repeatability)
Amplitude repeatability	±0.34 dB rms (example standard deviation at 10 kHz offset, 4% smoothing, medium video filtering. Can be reduced with more smoothing, filtering and averaging)
Video filtering	Four levels: None (VBW/RBW = 1.0) Little (VBW/RBW = 0.3) Medium (VBW/RBW = 0.1) Maximum (VBW/RBW = 0.03)
Smoothing	Fine-adjustable between 0% and 16%
rms noise calculation	rms phase deviation, rms phase jitter, and residual FM are calculated over a user-specified integration interval
System phase noise	See Figures 10 and 11.

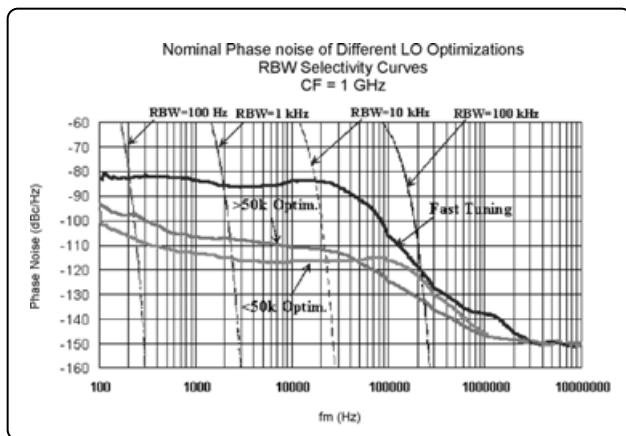


Figure 10. Nominal phase noise of different LO optimizations

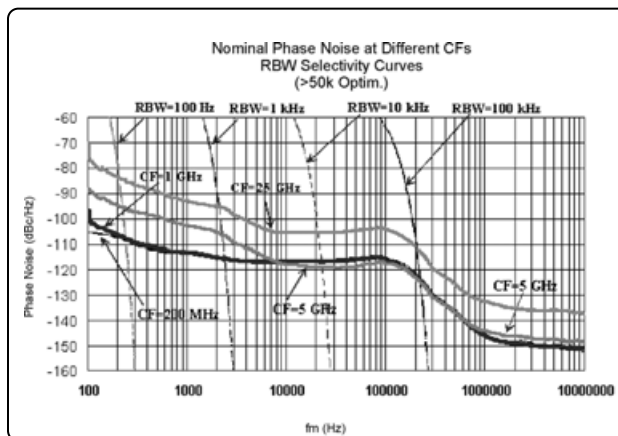


Figure 11. Nominal phase noise at different carrier frequencies (CFs)

1. See PSA Series spectrum analyzer data sheet for more specification details (literature number 5980-1284E).

Ordering Information

PSA Series spectrum analyzer

E4443A	3 Hz to 6.7 GHz
E4445A	3 Hz to 13.2 GHz
E4440A	3 Hz to 26.5 GHz
E4446A	3 Hz to 44 GHz
E4448A	3 Hz to 50 GHz

Options

To add options to a product, use the following ordering scheme:

Model	E444xA (x = 0, 3, 5, 6 or 8)
Example options	E4440A-B7J E4448A-1DS

Digital demodulation hardware

E444xA-B7J	Digital demodulation hardware (required for digital demodulation measurement personalities)
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Digital demodulation measurements

E444xA-BAF	W-CDMA measurement personality
E444xA-202	GSM w/ EDGE measurement personality
E444xA-B78	cdma2000 measurement personality
E444xA-204	1xEV-DO measurement personality
E444xA-BAC	cdmaOne measurement personality
E444xA-BAE	NADC, PCD measurement personality

General purpose measurements

E444xA-226	Phase noise measurement personality
E444xA-219	Noise figure measurement personality

Amplifiers

E444xA-1DS	100 kHz to 3 GHz built-in preamplifier
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Inputs and outputs

E4440A-BAB	Replaces type "N" input connector with APC 3.5 connector
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Connectivity software

E444xA-230	BenchLink Web Remote Control Software
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Warranty and service

For warranty and service of 5 years, please order 60 months of R-51B (quantity = 60). Standard warranty is 36 months.

R-51B	Return-to-Agilent warranty and service plan
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Calibration¹

For 3 years, order 36 months of the appropriate calibration plan shown below. For 5 years, specify 60 months.

R-50C-001	Standard calibration
R-50C-002	Standards compliant calibration

1. Options not available in all countries.

Product Literature

Selecting the Right Signal Analyzer for Your Needs, selection guide, literature number 5968-3413E

PSA Series literature

PSA Series, brochure, literature number 5980-1283E

PSA Series, data sheet, literature number 5980-1284E

Application literature

Spectrum Analysis Basics, application note 150, literature number 5952-0292E

Pulse Carrier Phase Noise Measurements, application note 1309, literature number 5968-2081E

For more information on the E4406A the PSA Series, please visit:

www.agilent.com/find/psa

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