Keysight Technologies
Phase Noise X-Series Measurement Application N9068A & W9068A

Technical Overview

KEYSIGHT TECHNOLOGIES

Introduction

- One-button, easy-to-use, fast phase noise measurements with log plot and spot frequency views
- Spectrum and IQ waveform monitoring for quick signal checks in frequency or time domain
- Supports the X-Series signal analyzers with external mixing for carrier frequencies beyond 50 GHz
- Hardkey/softkey manual user interface or SCPI remote user interface
- Built-in, context-sensitive help
- Transportable licensing between X-Series signal analyzers or MXE EMI receiver

Phase Noise Measurement Application

In addition to a superior combination of speed, accuracy, flexibility, and dynamic range, the Keysight Technologies, Inc. X-Series signal analyzers offer the broadest set of measurement applications. The phase noise measurement application is an ideal tool for design verification and troubleshooting as well as production line testing. This application is built upon Keysight's best-selling Option 226 phase noise measurement personality used in ESA and PSA spectrum analyzers and includes enhancements in measurement algorithms for optimized speed and dynamic range.

The phase noise measurement application is just one in a common library of more than 25 measurement applications in the Keysight X-Series, an evolutionary approach to signal analysis that spans instrumentation, measurements, and software. The X-Series analyzers and MXE EMI receiver, with upgradeable CPU, memory, removable solid-state drive, and I/O ports, enable you to keep your test assets current and extend instrument longevity. Proven algorithms, 100% code-compatibility, and a common UI across the X-Series create a consistent measurement framework for signal analysis that ensures repeatable results and measurement integrity so you can leverage your test system software through all phases of product development. In addition to fixed, perpetual licenses for our X-Series measurement applications, we also offer transportable licenses which can increase the value of your investment by allowing to you transport the application to multiple X-Series analyzers.

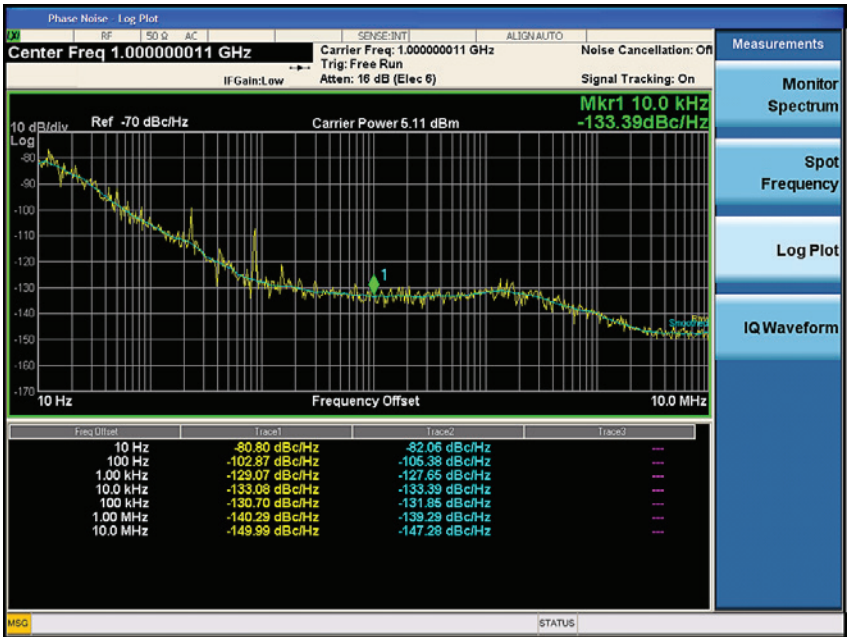

Figure 1. A complete solution for phase noise measurements

Phase Noise Measurement Overview

As wireless communication technologies evolve in the commercial and aerospace and defense industries, it is clear that the driver to meet demand for higher data rates, better spectrum efficiency, and lower power consumption is the digital technology, such as digital signal processing (DSP). It does not, however, devalue the importance of high-purity, high-stability signals—signal stability is fundamental to successful modern digital wireless communication systems. Phase noise is still one of the most important characteristics when evaluating the short-term stability of a signal. Pressure to bring products to market more quickly than ever does not allow time for executing multiple measurements across several instruments. An accurate, fast, and easy-to-use phase noise measurement tool is critical in the R&D and manufacturing environments.

A variety of measurement techniques have been developed to meet various requirements for phase noise measurements. The three most widely adopted techniques are: direct spectrum, phase detector, and two-channel cross-correlation. Among them, the direct spectrum technique is the simplest and perhaps oldest technique for making phase noise measurements.

Keysight's X-Series phase noise measurement application is based on the direct spectrum technique. The most obvious advantage using the direct spectrum technique for phase noise measurements is that it can be realized with a general-purpose signal/spectrum analyzer. However, the analyzer's settings, such as resolution bandwidth (RBW) and internal phase noise optimization loops, will need to be adjusted based on offset frequency to achieve the highest measurement accuracy and speed. Manually implementing phase noise measurements with a signal analyzer can be tedious and time consuming. The X-Series phase noise measurement application automates the optimization processes for the signal analyzer settings with one-button measurements without user interference.

Phase Noise Measurements

With the X-Series signal analyzers or MXE EMI receiver and the phase noise measurement application, you can easily perform phase noise analysis on various devices, such as local oscillators and signal sources. The analysis includes:

- **Log plot:** Single-sideband (SSB) phase noise view in frequency domain
- **Spot frequency:** Phase noise view in time domain including carrier frequency drift measurement
- **Monitor spectrum:** Easy-to-use simple spectrum view for a quick check of your signal
- **IQ waveform:** Easy-to-use simple time domain view

Measurement details

Log plot phase noise

Log plot measures SSB 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.

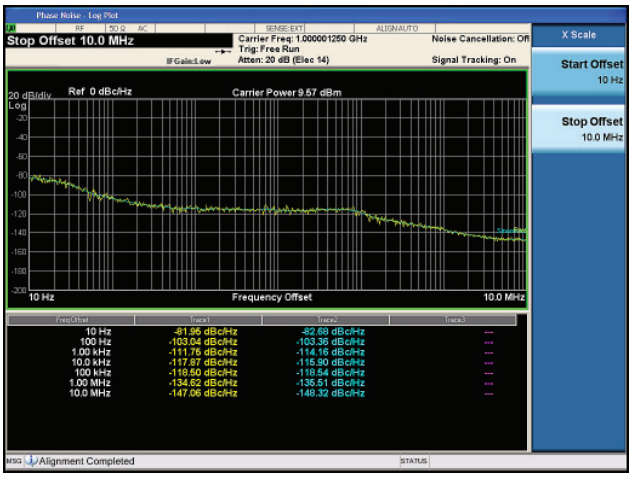

Figure 2. Log plot phase noise with a smoothed trace and decade table turned on (taken from an MXA with N9068A)

Log plot phase noise (continued)

View the entire phase noise behavior across a wide range of offset frequencies (1 Hz[1] to the difference between the maximum frequency of the analyzer and carrier frequency) and measure phase noise with a user-specified number of averages. Perform trace smoothing with user-adjustable smoothing segment length (Figure 1).

The log plot measurement function also includes:

– AM rejection, which works for offsets equal to or less than 1 MHz so that you observe only the phase component

– Overdrive function, which maximizes the dynamic range at offsets beyond 1 MHz, improving measurement accuracy by reducing the adverse effect of broadband noise

– Support of maximum frequency up to 50 GHz and beyond (with PXA and external mixing)

– A suite of advanced marker functions optimized for detailed log plot trace analysis

– Display of tabular readings (the decade table) in addition to the graphic presentation

– Automatic search of carrier function with Auto Tune

– Multi-level video filtering

1. *Requires Option AFP or ATP for previously purchased N/W9068A measurement application product.*

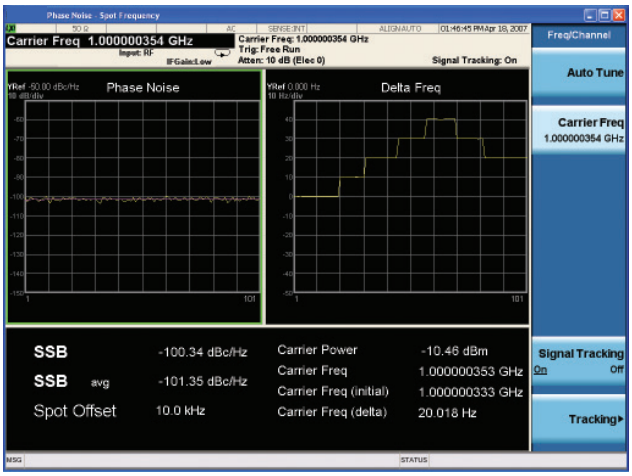

Figure 3. Carrier frequency drift view with phase noise vs. time

Spot frequency phase noise

After a particular frequency offset has been identified for further analysis, the spot frequency measurement provides the time domain behavior of phase noise at that particular offset (Figure 2).

The spot frequency measurement can be used to:

– Monitor phase noise fluctuation versus time at a user-specified single offset frequency

– Take advantage of improved carrier frequency tracking range with faster signal tracking

– View graphic and numeric list formats

– Find the signal from the full range of frequency with the X-Series' Auto Tune feature

The spot frequency signal tracking feature provides:

– A simultaneous view of phase noise and delta frequency in time domain

– SSB, average SSB, carrier power, carrier frequency, carrier frequency (initial), and carrier frequency delta in a table

Monitor spectrum

In addition to the phase noise measurements, you can verify the quality of the signal of interest without having to switch from the phase noise mode to the spectrum analyzer mode. The monitor spectrum measurement provides a simple frequency domain view for a quick signal check. In addition, the abundant marker/trace functions for the X-Series signal analyzers and MXE EMI receiver help better quantify the signal in frequency domain (Figure 3).

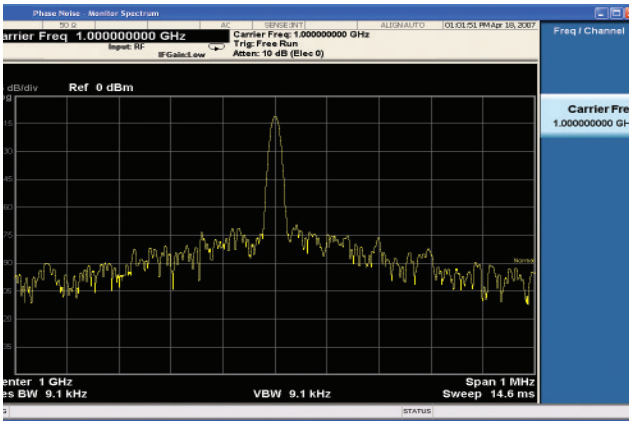

Figure 4. Monitor spectrum to check the signal coming from the DUT

IQ waveform

The phase noise X-Series measurement application employs IQ analysis, which maintains both amplitude and phase information of the signal under test. The IQ waveform measurement enables you to view the signal in time domain without having to switch modes between the phase noise and the IQ analyzer. This can significantly decrease your measurement time.

Advanced marker functions for Log Plot trace

The Log Plot measurement provides a wide range of advanced markers and marker functions so that you can analyze various aspects of the trace, such as integrated noise, averaged noise density, and residual FM across the applied band marker span, as well as multiple spurious-peak search functions and absolute, octave slope, and decade slope scale delta markers. See Figure 4 and the following tables for more detail.

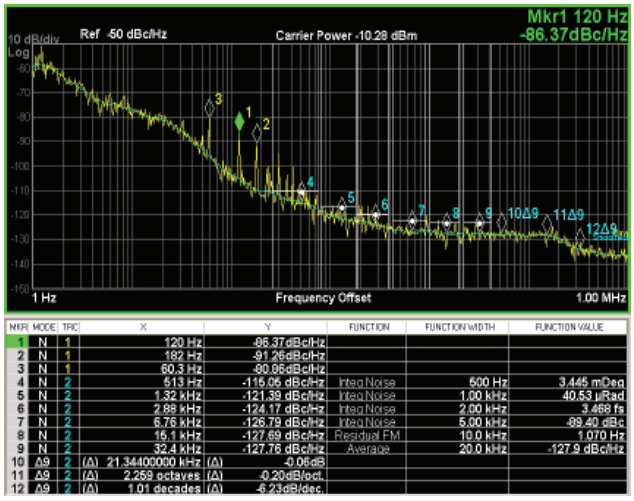

Figure 5. Apply a wide variety of advanced markers and marker functions, optimized for log plot trace analysis

Marker number	Marker functions
1 through 3	Normal markers, spurious search (#1: peak spur, #2: next spur right, #3: next spur left)
4	Band marker, RMS integrated phase deviation in degree
5	Band marker, RMS integrated phase deviation in radian
6	Band marker, RMS integrated jitter in radian
7	Band marker, RMS integrated phase noise in dBc per marker bandwidth Hz
8	Band marker, residual FM in Hz
9	Band marker, RMS averaged phase noise density in dBc per Hz
10Δ9	Delta marker, absolute (x) scale
11Δ9	Delta marker, octave slope (2x) scale
12Δ9	Delta marker, decade slope (10x) scale

Integrated noise measurement

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, residual FM is more important to amplifier designers and manufacturers. The X-Series signal analyzers make these measurements easy with advanced marker functions (Figure 4).

The band marker functions enable you to:

- Characterize phase noise related behaviors from different angles for various applications
- Adjust bandwidth for integrating noise power (in dB/bandwidth Hz)[1] or averaging noise power density (in dB/Hz)[1] by using advanced band markers on the log plot
- Calculate rms phase deviation (or residual PM) in degrees or radians
- Calculate rms jitter in seconds
- Calculate the residual FM in Hz
- View numeric marker readings for calculated results
- View readings of multiple markers

1. Requires Option AFP or ATP for previously purchased equipment.

Multiple spurious peak search

The marker menu supports the spurious peak search function[1], peak, next peak, right peak, and left peak. The "raw" trace (yellow) indicates that spurious signals are automatically detected and separated. The "smoothed" trace (light blue) remains after the spurious products are removed from the "raw" trace.

Advanced scaled delta markers

The delta marker menu enables you to select various scales of:

- Absolute/normal (x Hz)
- Octave slope (2x Hz)[1]
- Decade slope (10x Hz)[1]

Other measurement features

Displayed average noise level (DANL) measurements

The DANL floor of a signal/spectrum analyzer sets limitations for measuring the smallest input signal because it may negatively affect phase noise measurement accuracy at the far-out offset frequencies. When the amplitude of a signal under test gets closer to the DANL floor, a significant measurement error can occur, invalidating the measurement. To help ensure the measurement is valid, the phase noise measurement application measures the DANL floor noise plot (Figure 5).

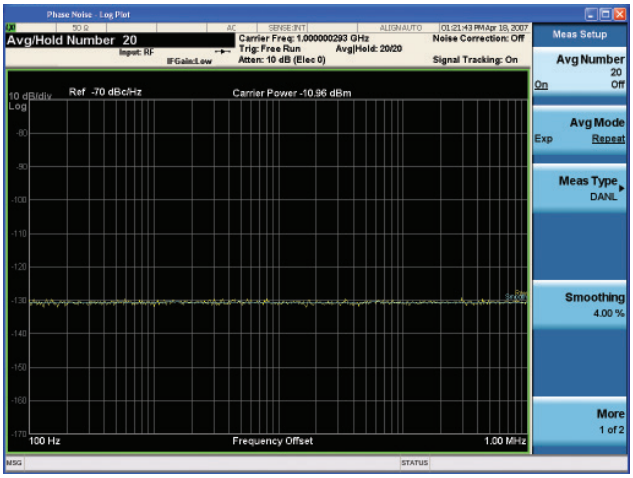

Figure 6. DANL measurement

The DANL measurement mode allows you to:

- Measure and reference the DANL of the X-Series signal analyzer to the carrier amplitude
- Display the DANL floor together with the log plot phase noise to determine the valid measurement range
- Easily store and recall traces

Reference trace subtractions

By using the trace subtraction function, you can subtract the DANL floor or phase noise of the X-Series signal analyzer or MXE EMI receiver.

DANL subtraction

Subtract the signal analyzer's internal broadband noise from the compounded measurement result to see the phase noise of the DUT at the offset frequency where the noise level of the signal analyzer and DUT is close. Recall the stored DANL data to subtract from measured data (Figure 6).

Figure 7. Phase noise plot with subtraction of DANL; the DANL trace is in magenta

Phase noise subtraction

The X-Series signal analyzers also feature phase noise subtraction. Using a source with low phase noise, you can eliminate the influence of the signal analyzer's internal phase noise on measurement results for close-in offset frequencies.

Use reference trace subtractions to:

– Improve measurement accuracy and sensitivity

– Make the best trade-off between cancellation effectiveness and computation time with user-selectable thresholds

By using the trace subtraction function, you can subtract the DANL floor or phase noise of the X-Series signal analyzer.

Phase noise measurements up to 50 GHz and beyond

When the N9068A phase noise measurement application is installed in the N9030A PXA high-performance signal analyzer, one-button phase noise measurements up to 50 GHz can be made. Furthermore, when installed in a PXA with external mixing Option EXM or the millimeter-wave EXA with Option EXM, and an external mixer (such as the Keysight M1970V USB smart mixer), the N9068A can perform phase noise measurements covering the carrier frequency up to 110 GHz or even higher. The automated DANL measurement is not available for external mixing (Figure 7).

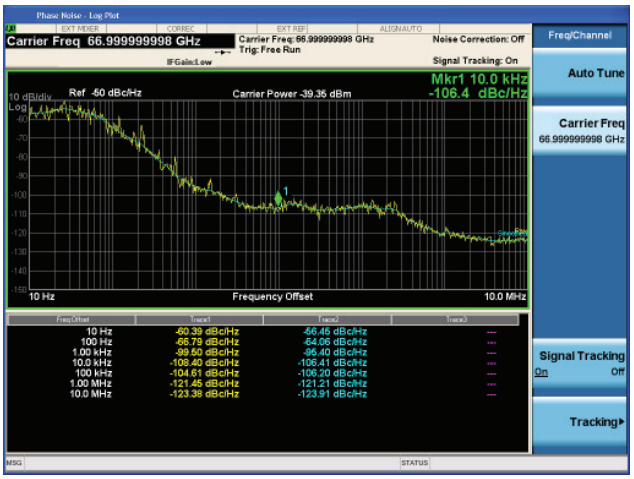

Figure 8. Phase noise measurement at 67 GHz with PXA Option EXM and an external mixer

Key Specifications

Definitions

- Specifications describe the performance of parameters covered by the product warranty.
- 95th percentile values indicate the breadth of the population (≈2σ) of performance tolerances expected to be met in 95% of cases with a 95% confidence. These values are not covered by the product warranty.
- Typical values are designated with the abbreviation "typ." These are performance beyond specification that 80% of the units exhibit with a 95% confidence. These values are not covered by the product warranty.
- Nominal values are designated with the abbreviation "nom." These values indicate expected performance, or describe product performance that is useful in the application of the product, but is not covered by the product warranty.

Note: Data subject to change

Description	PXA	MXA	EXA	CXA	MXE
Measurement modes	Log plot, spot frequency, spectrum monitor, and IQ waveform				
Maximum carrier frequency	Opt 503: 3.6 GHz Opt 508: 8.4 GHz Opt 513: 13.6 GHz Opt 526: 26.5 GHz Opt 543: 43 GHz Opt 544: 44 GHz Opt 550: 50 GHz Opt EXM: > 50 GHz	Opt 503: 3.6 GHz Opt 508: 8.4 GHz Opt 513: 13.6 GHz Opt 526: 26.5 GHz	Opt 503: 3.6 GHz Opt 507: 7.0 GHz Opt 513: 13.6 GHz Opt 526: 26.5 GHz Opt 532: 32 GHz[1] Opt 544: 44 GHz[1]	Opt 503: 3.0 GHz Opt 507: 7.5 GHz Opt 513: 13.6 GHz Opt 526: 26.5 GHz	Opt 508: 8.4 GHz Opt 526: 26.5 GHz
Offset frequency range					
Minimum offset frequency	1 Hz[2]				
Maximum offset frequency	(f_{opt} - f_{cf}) Hz, where f_{opt} is the max frequency of the analyzer's frequency option, and fcf the carrier frequency of the signal under test				
Maximum number of decades	Depends on frequency offset range				
Measurment accuracy					
Phase noise density accuracy	± 0.2 dB	± 0.3 dB	± 0.5 dB	± 0.9 dB	
Offset frequency accuracy	± 0.5%	± 0.5%	± 0.5%	± 0.5%	
Smoothing	Fine-adjustable between 0% and 16%				
rms noise calculation	rms phase deviation, rms jitter, residual FM, rms noise power[1], and integrated noise power[1] are calculated over a user-defined integral interval				
Base instrument phase noise (Typical with center frequency = 1 GHz)					
Offset frequency					
100 Hz	–100 dBc/Hz	–91 dBc/Hz	–84 dBc/Hz	N.A.	
1 kHz	–125 dBc/Hz	–112 dBc/Hz (nom.)	–98 dBc/Hz (nom.)	–103 dBc/Hz	
10 kHz	–132 dBc/Hz	–113 dBc/Hz	–103 dBc/Hz	–110 dBc/Hz	
100 kHz	–131 dBc/Hz	–116 dBc/Hz	–115 dBc/Hz	–110 dBc/Hz	
1 MHz	–146 dBc/Hz	–135 dBc/Hz	–135 dBc/Hz	–130 dBc/Hz	
10 MHz	–158 dBc/Hz	–148 dBc/Hz (nom.)	–148 dBc/Hz (nom.)	–145 (nom.) dBc/Hz	

1. *Base instrument phase noise performance at 1 GHz for mmW EXA is slightly different from that for RF/uW EXA. Refer to EXA specifications guide for more details.*
2. *Requires Option AFP or ATP for previously purchased equipment*

Key Specifications (continued)

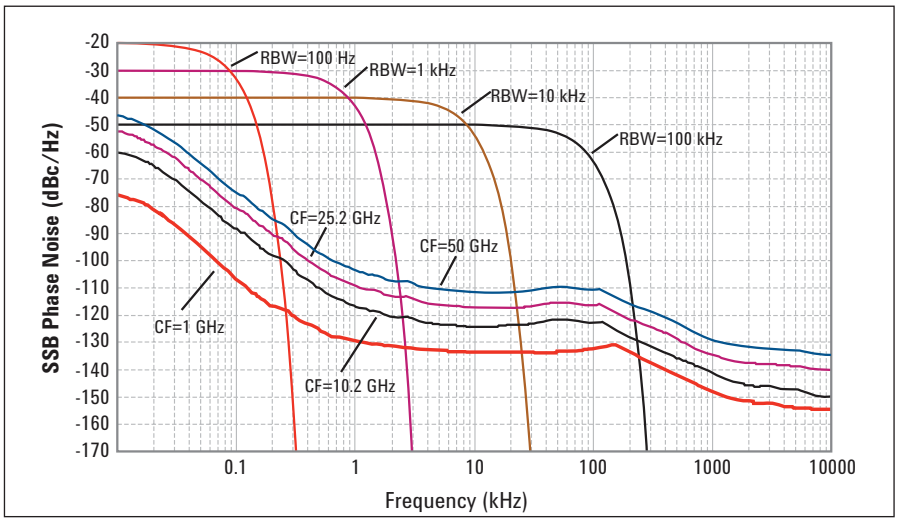

Figure 9. PXA (N9030A) nominal phase noise at various center frequencies

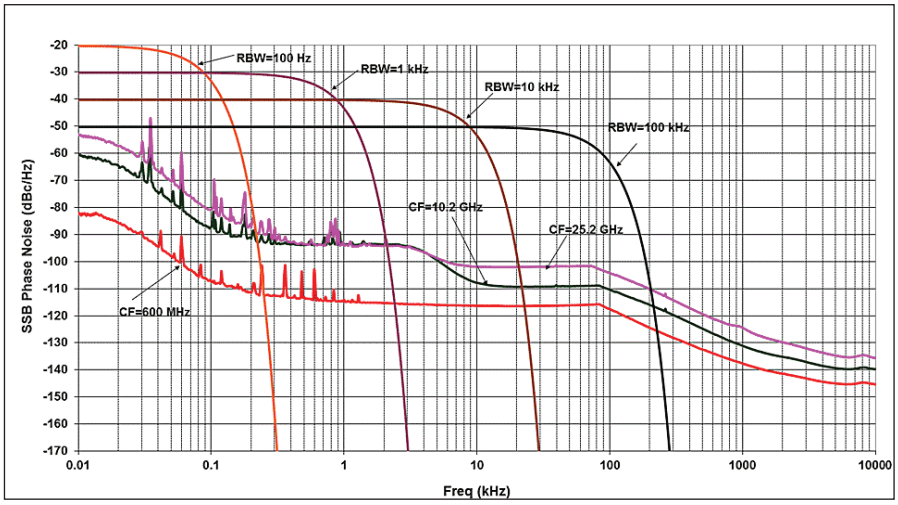

Figure 10. MXA (N9020A) nominal phase noise at different center frequencies

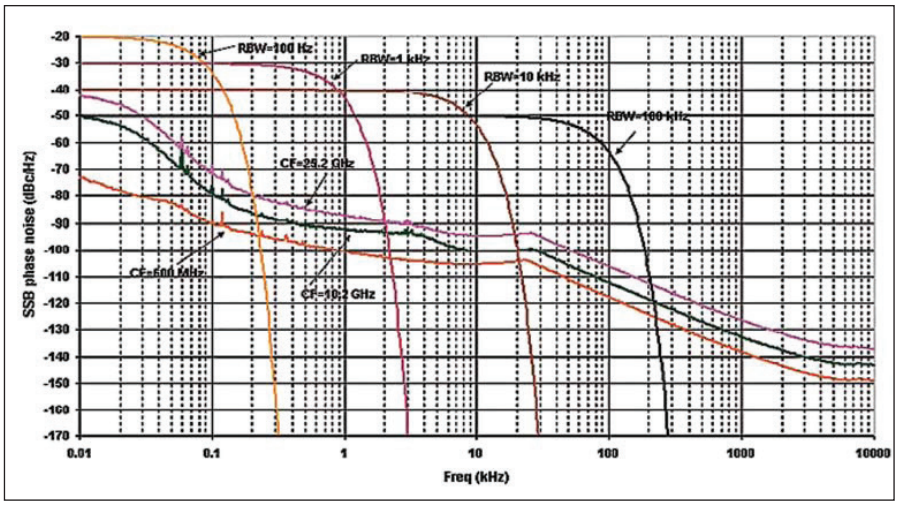

Figure 11. RF/MW EXA (Option N9010A-503, 507, 513, 526) nominal phase noise at different center frequencies

Key Specifications (continued)

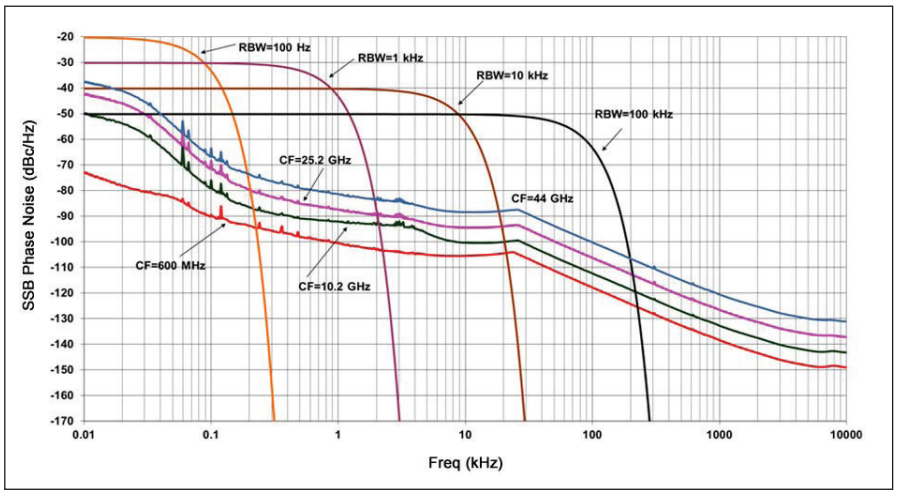

Figure 12. Millimeter-wave (mmW) EXA (Option N9010A-532, 544) nominal phase noise at different center frequencies

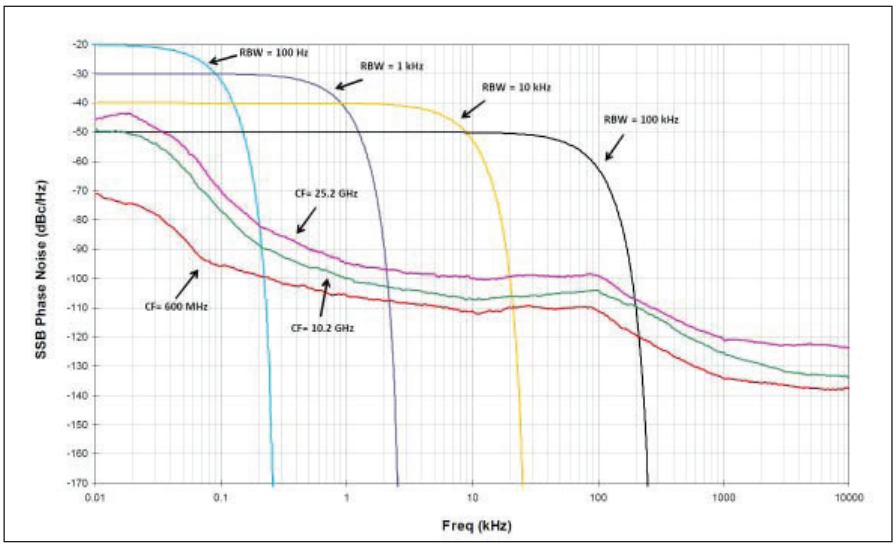

Figure 13. RF CXA (Opt. 503, 507) nominal phase noise at different center frequencies

Ordering Information

Software licensing and configuration

Choose from two license types:

– **Fixed, perpetual license:**
This allows you to run the application in the X-Series analyzer in which it is initially installed.

– **Transportable, perpetual license:**
This allows you to run the application in the X-Series analyzer in which it is initially installed, plus it may be transferred from one X-Series analyzer to another.

www.keysight.com/find/X-series_trial

The table below contains information on our fixed, perpetual licenses. For more information, please visit the product web pages.

N9068A & W9068A phase noise X-Series measurement application

Description	Model-Option		Additional information
	PXA, MXA, EXA	CXA	
Phase noise	N9068A-2FP	W9068A-2FP	
Phase noise feature enhancements	N9068A-AFP	W9068A-AFP	Option AFP is for upgrades only. Enhancements are standard with purchase of new N/W9068A.

www.keysight.com/find/N9068A-MEU

www.keysight.com/find/W9068A-MEU

Hardware configuration

N9030A PXA signal analyzer

Description	Model-Option	Additional information
3.6, 8.4, 13.6, 26.5, 43, 44, or 50 GHz frequency range	N9030A-503, -508, -513, -526, -543, -544, or -550	One required
External mixing	N9030A-EXM	One required

N9020A MXA signal analyzer

Description	Model-Option	Additional information
3.6, 8.4, 13.6, or 26.5 GHz frequency range	N9020A-503, -508, -513, or -526	One required

N9010A EXA signal analyzer

Description	Model-Option	Additional information
3.6, 7.0, 13.6, 26.5, 32, or 44 GHz frequency range	N9010A-503, -507, -513, -526, -532, or -544	One required
External mixing	N9010A-EXM (only available for frequency range options -532 and -544)	One required

N9000A CXA signal analyzer

Description	Model-Option	Additional information
3.0, 7.5, 13.6, or 26.5 GHz frequency range	N9000A-503, -507, -513, or -526	One required

N9038A MXE EMI receiver

Description	Model-Option	Additional information
8.4 or 26.5 GHz	N9038A-508, 526	One required

For a complete list of specifications refer to the appropriate specifications guide.

PXA: www.keysight.com/find/pxa_specifications

MXA: www.keysight.com/find/mxa_specifications

EXA: www.keysight.com/find/exa_specifications

CXA: www.keysight.com/find/cxa_specifications

MXE: www.keysight.com/find/mxe_specifications

Related Literature

N9068A & W9068A phase noise measurement application measurement guide, literature number N9068-90011

Phase Noise Measurement Selection Guide, literature number 5990-5725EN

Web

Product page:
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