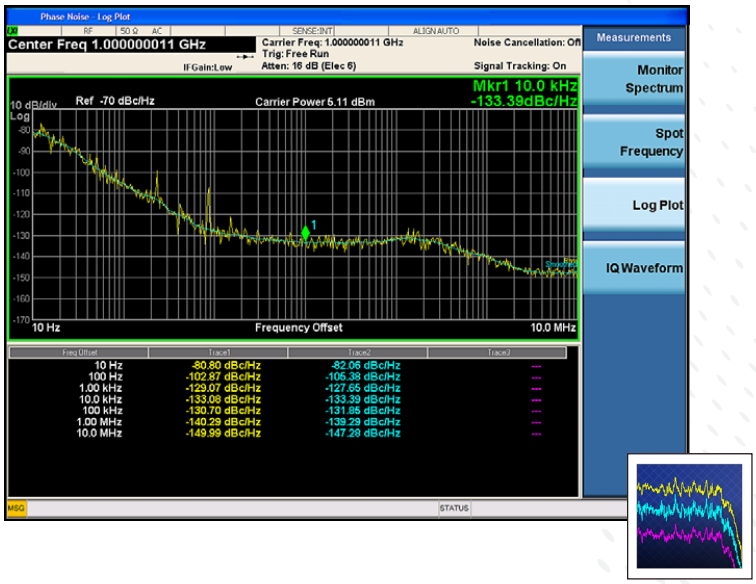
TECHNICAL OVERVIEW

N9068EMOD Phase Noise X-Series Measurement App, Traditional UI

- 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
- Flexible licensing provides the option of using perpetual or time based licenses with one or multiple signal analyzers



KEYSIGHT TECHNOLOGIES

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.

X-Series measurement applications

X-Series measurement applications increase the capability and functionality of Keysight signal analyzers to speed time to insight. They provide essential measurements for specific tasks in general-purpose, cellular communications, wireless connectivity and digital video applications, covering more than 40 standards or modulation types. Applications are supported on both benchtop and modular, with the only difference being the level of performance achieved by the hardware you select. X-Series measurement applications can help you:

- Gain more insight into device performance with intuitive display and graphs for your application. Select from our library of over 25 different measurement applications.
- Ensure that your design meets the latest standard. Updates are made to the X-Series measurement applications as standards evolve.
- Apply the same measurement science across multiple hardware platforms for consistent measurement results over your design cycle from R&D to production.
- Choose the license structure that meets your business needs. We provide a range of license types (node-locked, transportable, floating or USB portable) and license terms (perpetual or time-based).

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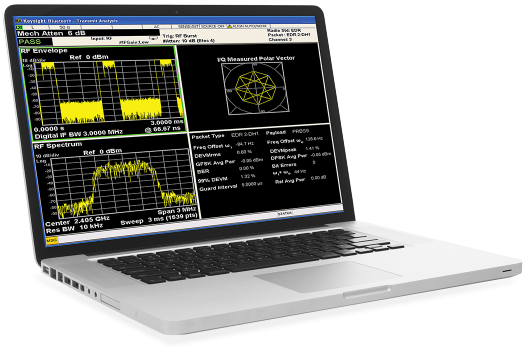


Phase Noise Measurement Overview

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 mea-surement 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.

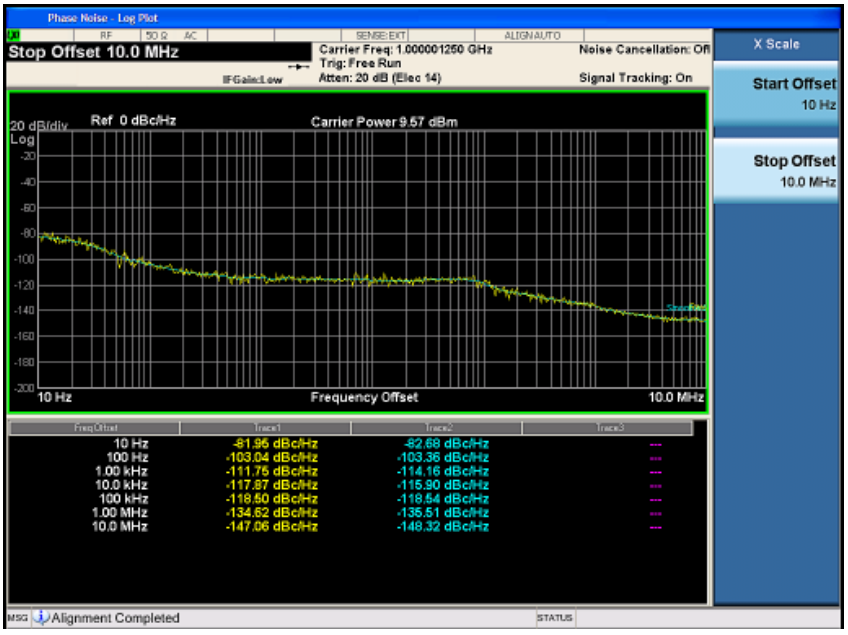


Figure 1. Log plot phase noise with a smoothed trace and decade table turned on (taken from an MXA with N9068EM0D).

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.

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
- Result trace hold with Off, Max hold or min hold
- Result trace filter On/Off, if on you can specify the high cutoff frequency and slope, low cutoff frequency and slope

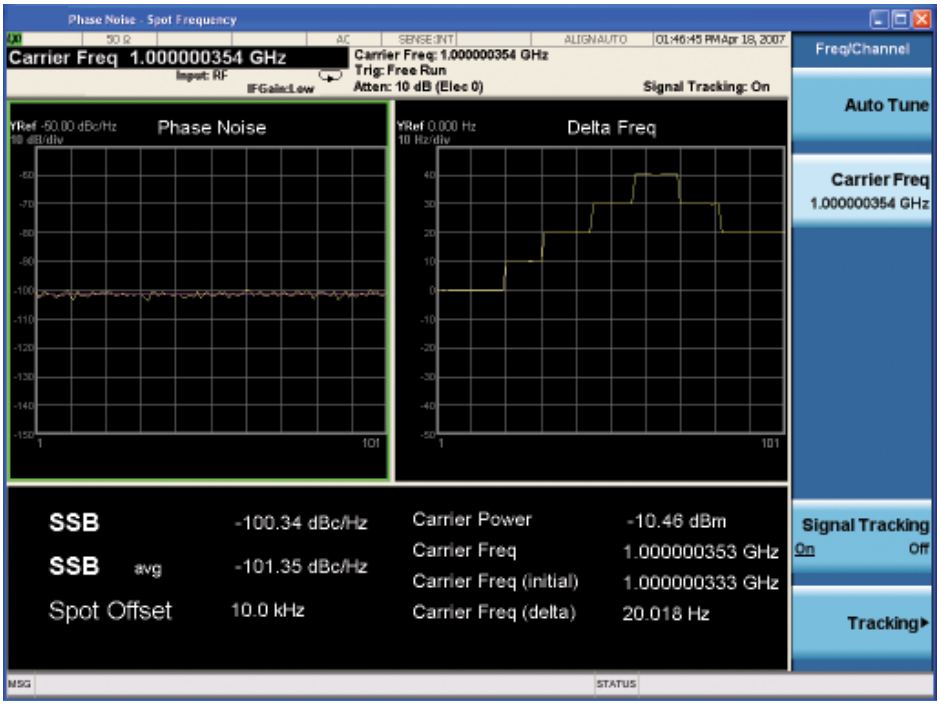


Figure 2. Carrier frequency drift view with phase noise vs. time.

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 1).

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

1. Requires Option AFP or ATP for previously purchased N9068EM0D measurement application product.

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 2).

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 3 and the following tables for more detail.

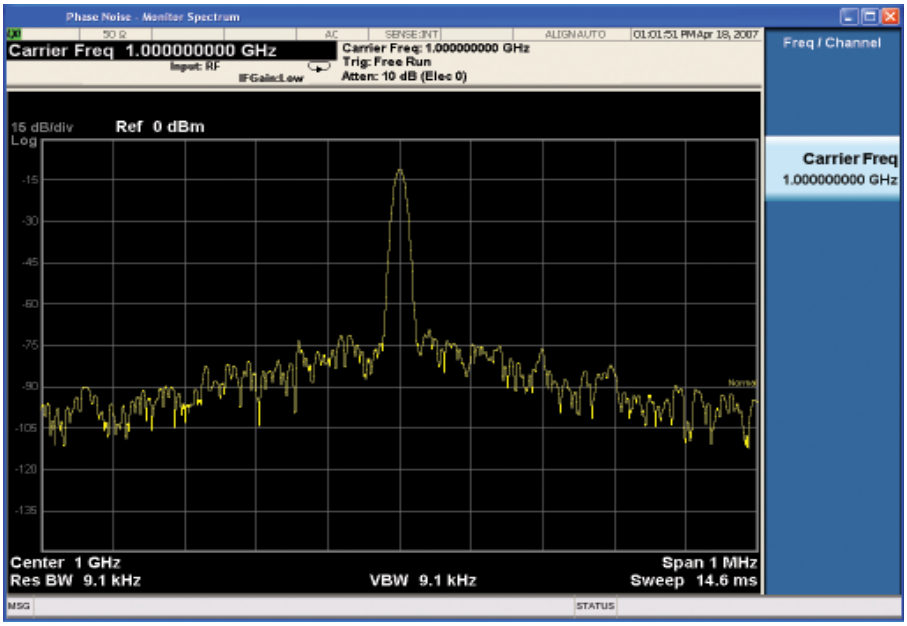
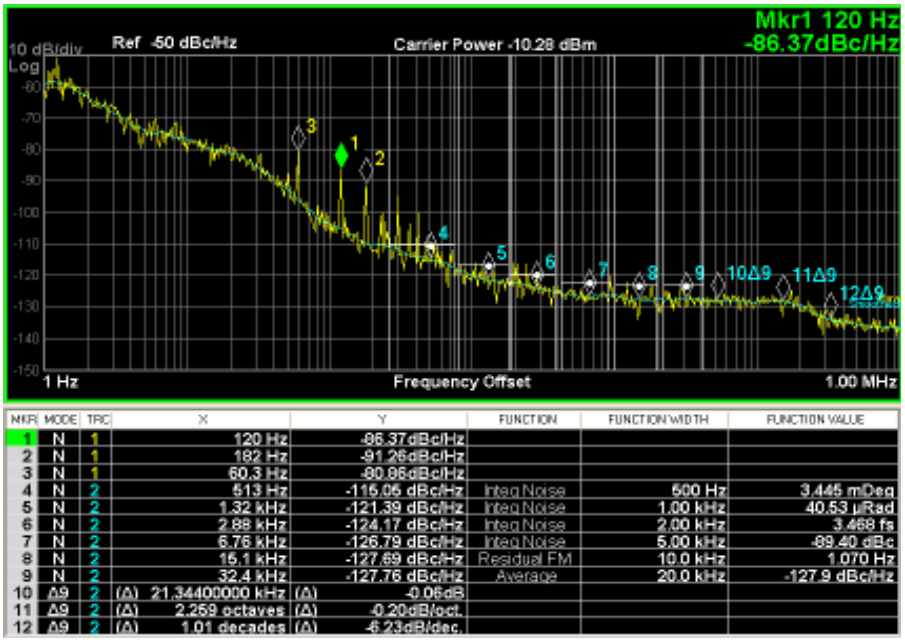


Figure 3. Monitor spectrum to check the signal coming from the DUT.



MKR	MODE	TRC	X	Y	FUNCTION	FUNCTION WIDTH	FUNCTION VALUE
1	N	1	120 Hz	-86.37 dBc/Hz			
2	N	1	182 Hz	-91.26 dBc/Hz			
3	N	1	60.3 Hz	-80.86 dBc/Hz			
4	N	2	513 Hz	-115.05 dBc/Hz	Integ Noise	500 Hz	3.445 mDeg
5	N	2	1.32 kHz	-121.39 dBc/Hz	Integ Noise	1.00 kHz	40.53 µRad
6	N	2	2.88 kHz	-124.17 dBc/Hz	Integ Noise	2.00 kHz	3.468 fs
7	N	2	6.76 kHz	-126.79 dBc/Hz	Integ Noise	5.00 kHz	-89.40 dBc
8	N	2	15.1 kHz	-127.69 dBc/Hz	Residual FM	10.0 kHz	1.070 Hz
9	N	2	32.4 kHz	-127.76 dBc/Hz	Average	20.0 kHz	-127.9 dBc/Hz
10	Δ9	2	(Δ) 21.34400000 kHz	(Δ) -0.06 dB			
11	Δ9	2	(Δ) 2.259 octaves	(Δ) -0.20 dB/oct			
12	Δ9	2	(Δ) 1.01 decades	(Δ) -6.23 dB/dec			

Figure 4. 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 3).

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

Multiple spurious peak search

The marker menu supports the spurious peak search function1, 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]

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

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, invalid-ating the measurement. To help ensure the measurement is valid, the phase noise measurement application measures the DANL floor noise plot (Figure 4).

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
- If carrier is measured in the past, later you can measure the DANL floor without input signal

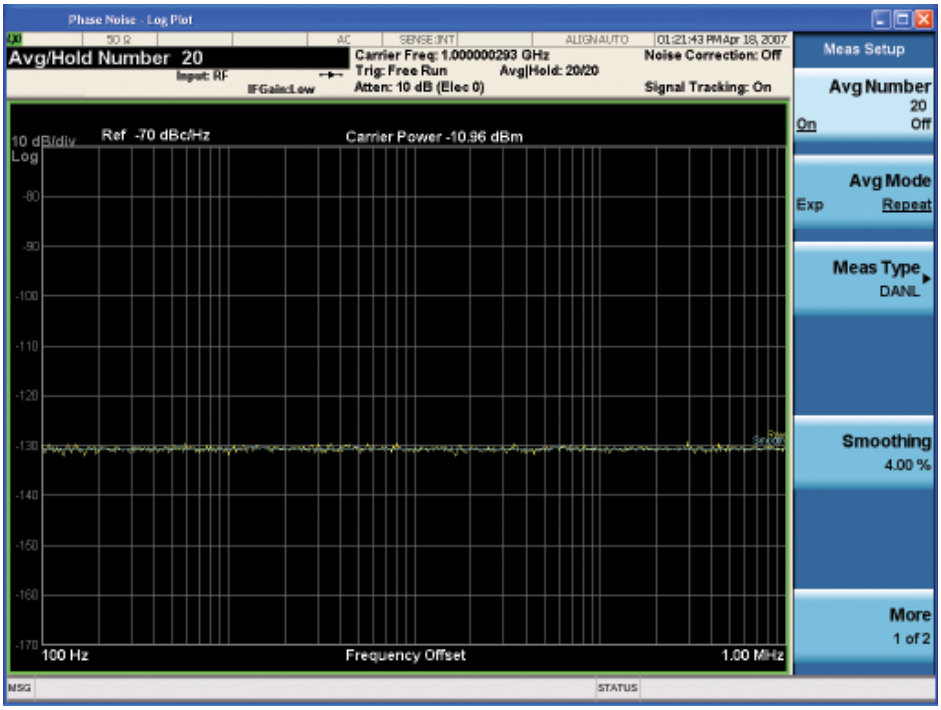


Figure 5. DANL measurement.

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 5).

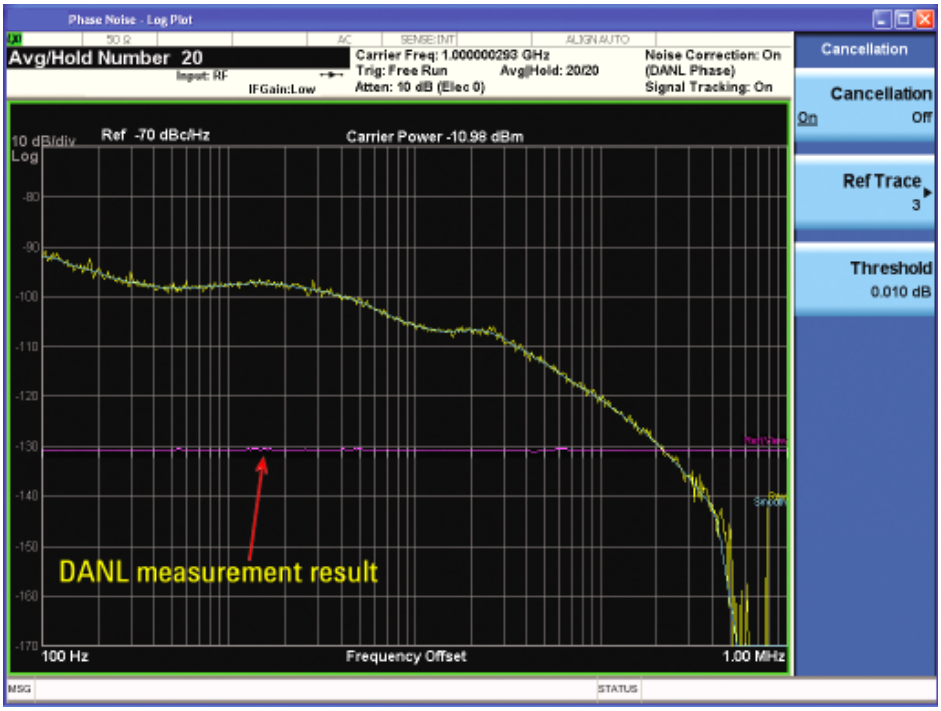


Figure 6. Phase noise plot with subtraction of DANL; the DANL trace is in magenta.

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 N9068EM0D 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 N9068EM0D 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 6).

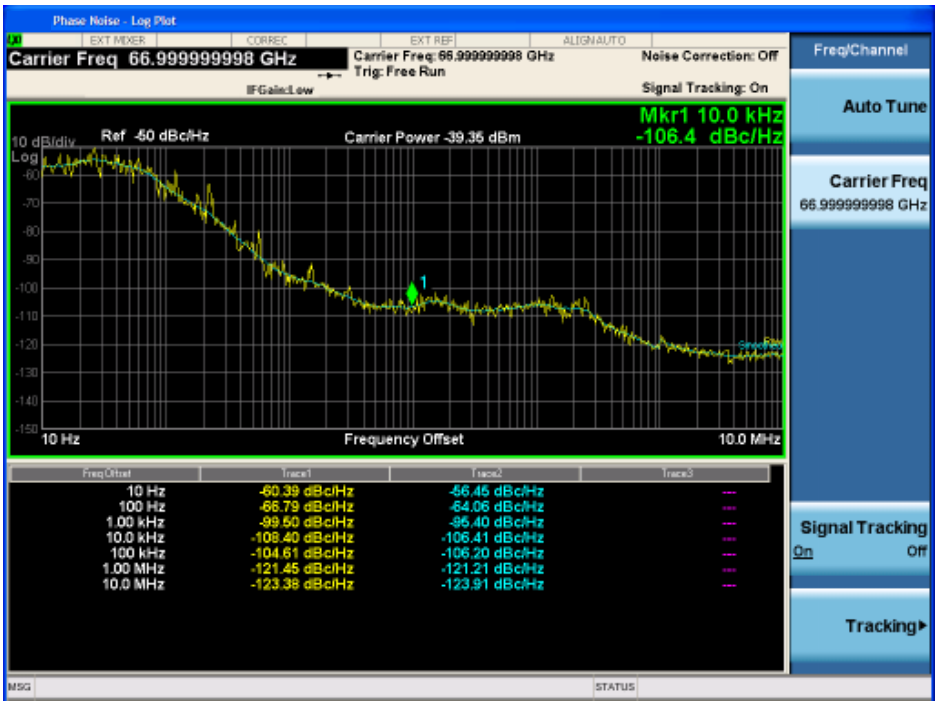


Figure 7. Phase noise measurement at 67 GHz with PXA Option EXM and an external mixer.

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	CXA-m	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 GHz1 Opt 544: 44 GHz1	Opt 503: 3.0 GHz Opt 507: 7.5 GHz Opt 513: 13.6 GHz Opt 526: 26.5 GHz	Opt F03: 3.0 GHz Opt F07: 7.5 GHz Opt F13: 13.6 GHz Opt F26: 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 f_{cf} the carrier frequency of the signal under test					
Maximum number of decades	Depends on frequency offset range					
Measurement accuracy						
Phase noise density accuracy	± 0.2 dB	± 0.3 dB	± 0.5 dB	± 0.9 dB	± 1.06 dB	
Offset frequency accuracy	± 0.5%	± 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 power1, and integrated noise power1 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	– 90 (nom) dBc/Hz	
– 1 kHz	–125 dBc/Hz	–112 dBc/Hz (nom)	–98 dBc/Hz (nom)	–103 dBc/Hz	–105 dBc/Hz	
– 10 kHz	–132 dBc/Hz	–113 dBc/Hz	–103 dBc/Hz	–110 dBc/Hz	–110 dBc/Hz	
– 100 kHz	–131 dBc/Hz	–116 dBc/Hz	–115 dBc/Hz	–110 dBc/Hz	–110 dBc/Hz	
– 1 MHz	–146 dBc/Hz	–135 dBc/Hz	–135 dBc/Hz	–130 dBc/Hz	–132 dBc/Hz	
– 10 MHz	–158 dBc/Hz	–148 dBc/Hz (nom)	–148 dBc/Hz (nom)	–145 (nom) dBc/Hz	–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)

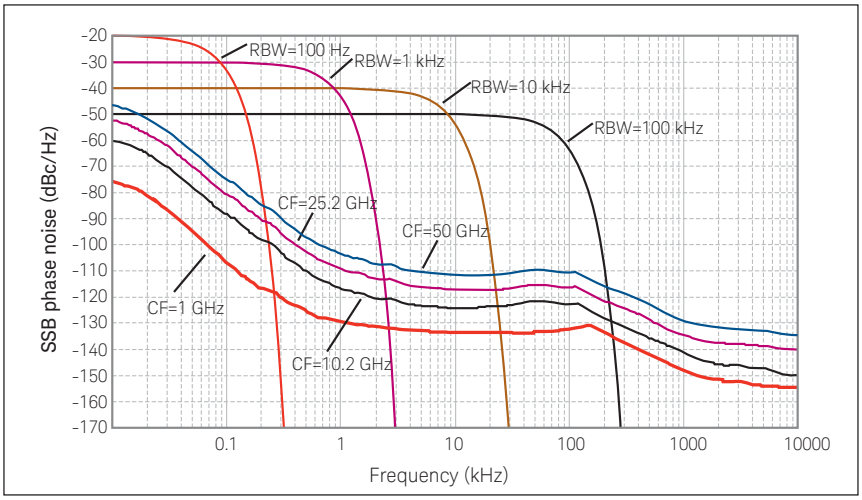


Figure 8. PXA (N9030A) nominal phase noise at various center frequencies.

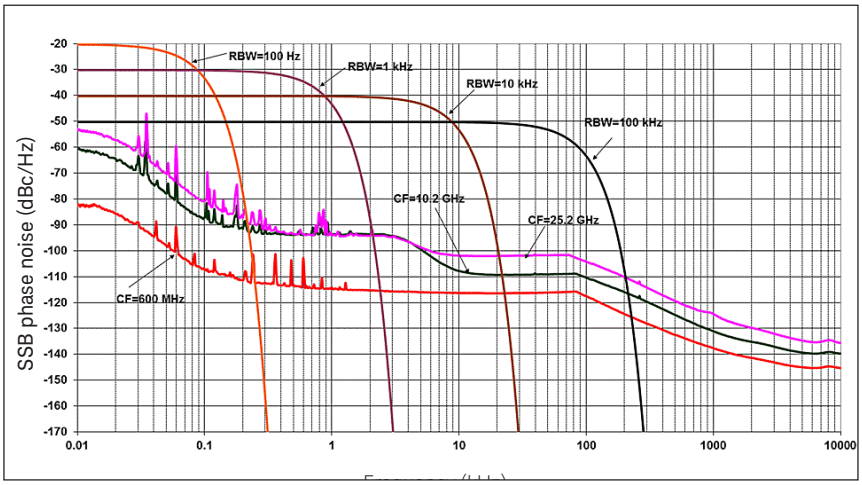


Figure 9. MXA (N9020A) nominal phase noise at different center frequencies.

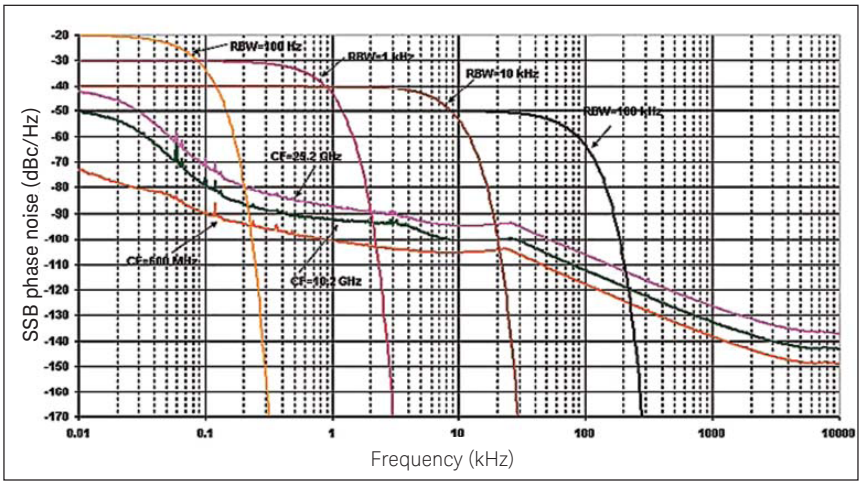


Figure 10. RF/MW EXA (Option N9010A-503, 507, 513, 526) nominal phase noise at different center frequencies.

Key Specifications (Continued)

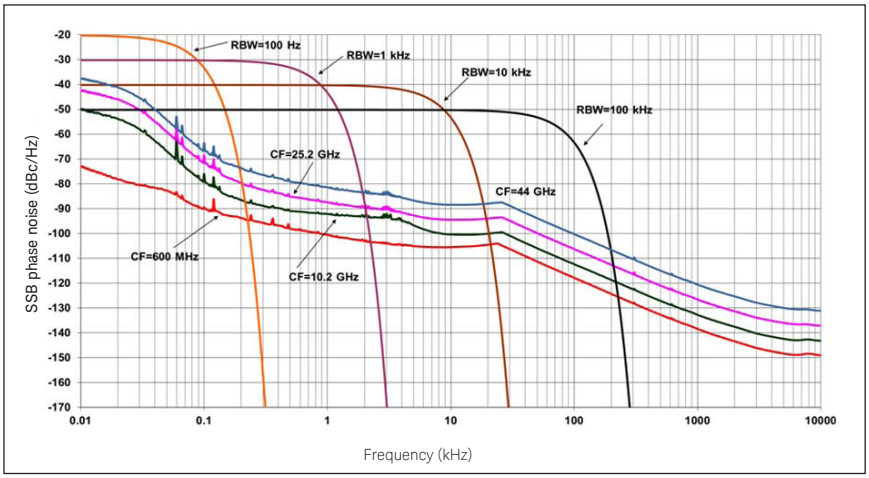


Figure 11. Millimeter-wave (mmW) EXA (Option N9010A-532, 544) nominal phase noise at different center frequencies.

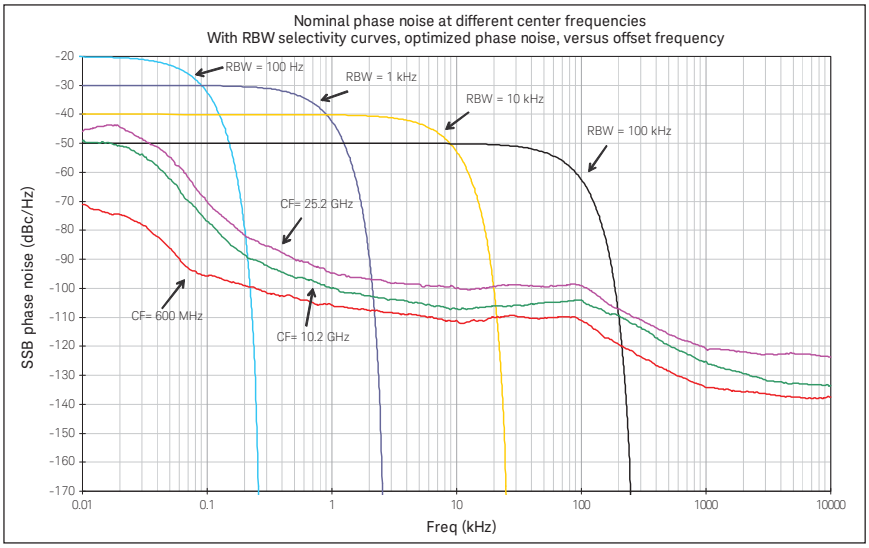


Figure 12. CXA (N9000A) nominal phase noise at different center frequencies.

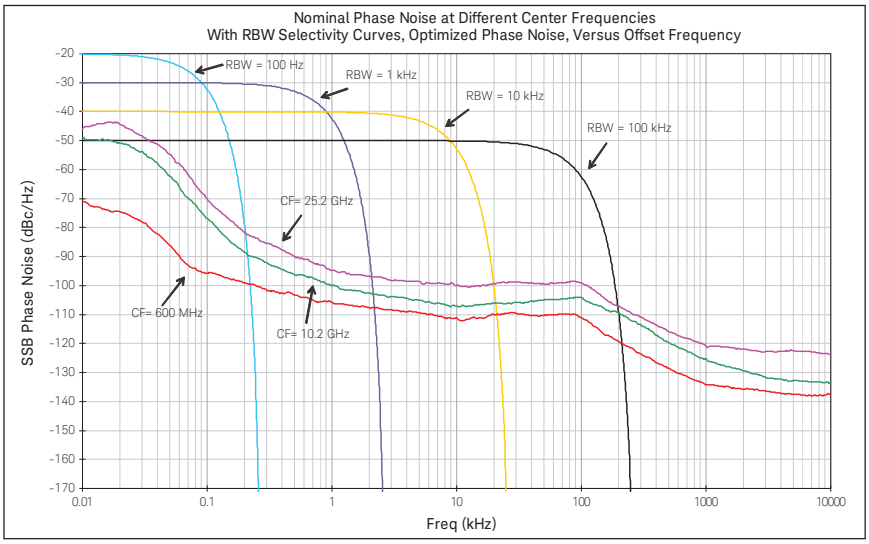


Figure 13. CXA-m (M9290A) nominal phase noise at different center frequencies.

Ordering Information

Flexible licensing and configuration

- **Perpetual:** License can be used in perpetuity.
- **Time-based:** License is time limited to a defined period, such as 12-months.
- **Node-locked:** Allows you to use the license on one specified instrument/computer.
- **Transportable:** Allows you to use the license on one instrument/computer at a time. This license may be transferred to another instrument/computer using Keysight's online tool.
- **Floating:** Allows you to access the license on networked instruments/computers from a server, one at a time. For concurrent access, multiple licenses may be purchased.
- **USB portable:** Allows you to move the license from one instrument/computer to another by end-user only with certified USB dongle, purchased separately.
- **Software support subscription:** Allows the license holder access to Keysight technical support and all software upgrades.

Phase noise measurement application (N9068EM0D)

Software license type	Software license	Support subscription (12-month) [1, 2]
Node-locked perpetual	R-Y5C-001-A [2]	R-Y6C-001-L [2]
Node-locked 12-month	R-Y4C-001-L [1]	Included
Transportable perpetual	R-Y5C-004-D [2]	R-Y6C-004-L [2]
Transportable 12-month	R-Y4C-004-L [1]	Included
Floating perpetual	R-Y5C-002-B [2]	R-Y6C-002-L [2]
Floating 12-month	R-Y4C-002-L [1]	Included
USB portable perpetual	R-Y5C-005-E [2]	R-Y6C-005-L [2]
USB portable 12-month	R-Y4C-005-L [1]	Included

One month software support subscription extensions [3]

Model	Description
R-Y6C-501 [3]	1-month of software support subscription for node-locked license
R-Y6C-502 [3]	1-month of software support subscription for floating license
R-Y6C-504 [3]	1-month of software support subscription for transportable license
R-Y6C-505 [3]	1-month of software support subscription for USB portable license

1. All time-based X-Series measurement application licenses includes a 12-month support contract which also includes the 12-month software support subscription as same duration.
2. Support contract must bundle software support subscription for all perpetual licenses in the first year. All software upgrades and Keysight support are provided for software licenses with valid support subscription.
3. After the first year, software support subscription may be extended with annual or monthly software support subscription extension.

You can upgrade!

All of our X-Series application options are license-key upgradeable.

UP GRADE

Try before you buy!

Evaluate a full-featured version of our X-Series measurement application with our *FREE* trial. Redeem one 30-day trial license of each measurement application online at: **www.keysight.com/find/X-Series_apps_trial**

Hardware configurations

To learn more about compatible platforms and required configurations, please visit: **www.keysight.com/find/X-Series_apps_platform**

Software models and options

To learn more about X-Series measurement application licensing, model numbers and options, please visit: **www.keysight.com/find/X-Series_apps_model**

Hardware Configuration

For optimizing the phase noise measurement application, Keysight recommends a minimum level of instrument hardware functionality at each instrument performance point. Supported instruments include:

Benchtop:

- PXA N9030A
- MXA N9020A
- MXE M9038A
- EXA N9010A
- CXA N9000A

PXIe:

- VSA (6 GHz) M9391A
- VSA (50 GHz) M9393A
- VXT M9420/21A
- CXA-m M9290A

N90x0A X-Series signal analyzer

Capability	Instrument option	Benefit
Analysis bandwidth	10 or 25 MHz as default or higher	**Required**: Wider analysis bandwidth options such as 25/40/85/125/160 MHz can be selected depending on the specified signal analyzer model
Precision frequency reference	-PFR	**Recommended**: For enhanced frequency accuracy and repeatability for lower measurement uncertainty
Electronic attenuator	-EA3	**Recommended**: Fast and reliable attenuation changes ideal for manufacturing without the wear associated with mechanical attenuators up to 3.6 GHz in 1 dB steps
Pre-amplifier	3.6 GHz (-P03) or higher	**Recommended**: For maximizing the measurement sensitivity
Fine resolution step attenuator	-FSA	**Recommended**: Useful for maximizing useable dynamic range to see signals
Analog baseband I/Q inputs	-BBA on PXA and MXA only	**Optional**: To extend measurements at baseband if required by device under test

M9391/93A PXIe VSA vector signal analyzer

Description	Model-Option	Additional information
Frequency range 3 or 6 GHz	M9391A-F03, or F06	One required for M9391A
Frequency range 8.4, 14, 18, or 27 GHz	M9393A-F08, F14, F18, or F27	One required for M9393A
Frequency extension to 43.5 or 50 GHz	M9393A-FRZ or FRX	Optional (requires M9393A-F27)
Analysis bandwidth 40, 100 or 160 MHz	M9391A/M9393A-B04, B10 or B16	One required
Memory 128, 512 or 1024 MSa	M9391A/M9393A-M01, M05 or M10	One required
Frequency reference 10 MHz and 100 MHz	M9391A/M9393A-300	One required

M9290A CXA-m PXIe signal analyzer

Description	Model-Option	Additional information
Frequency range 3, 7.5, 13.6 or 26.5 GHz	M9290A-F03, F07, F13, or F26	One required
Analysis bandwidth 25 MHz	M9290A-B25	Optional
Preamplifier, 3, 7.5, 13.6 or 26.5 GHz	M9290A-P03, P07, P13 or P26	One required
Fine resolution step attenuator	M9290A-FSA	Optional
Precision frequency reference	-PFR	Optional

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**
- CXA-m: **www.keysight.com/find/cxa-m_specifications**
- PXIe VSA up to 6 GHz: **www.keysight.com/find/m9391a**
- PXIe VSA up to 50 GHz: **www.keysight.com/find/m9393a**

Related Literature

Publication title	Publication number
N9068A & W9068A Phase Noise Measurement - Application Measurement Guide	N9068-90011
Phase Noise Measurement Solutions - Selection Guide	5990-5729EN

Web

Product page:
- www.keysight.com/find/n9068d

X-Series measurement applications:
- www.keysight.com/find/X-Series_Apps

X-Series signal analyzers:
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MXE EMI receiver:
- www.keysight.com/find/MXE

CXA-m PXIe signal analyzer:
- www.keysight.com/find/CXA-m

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