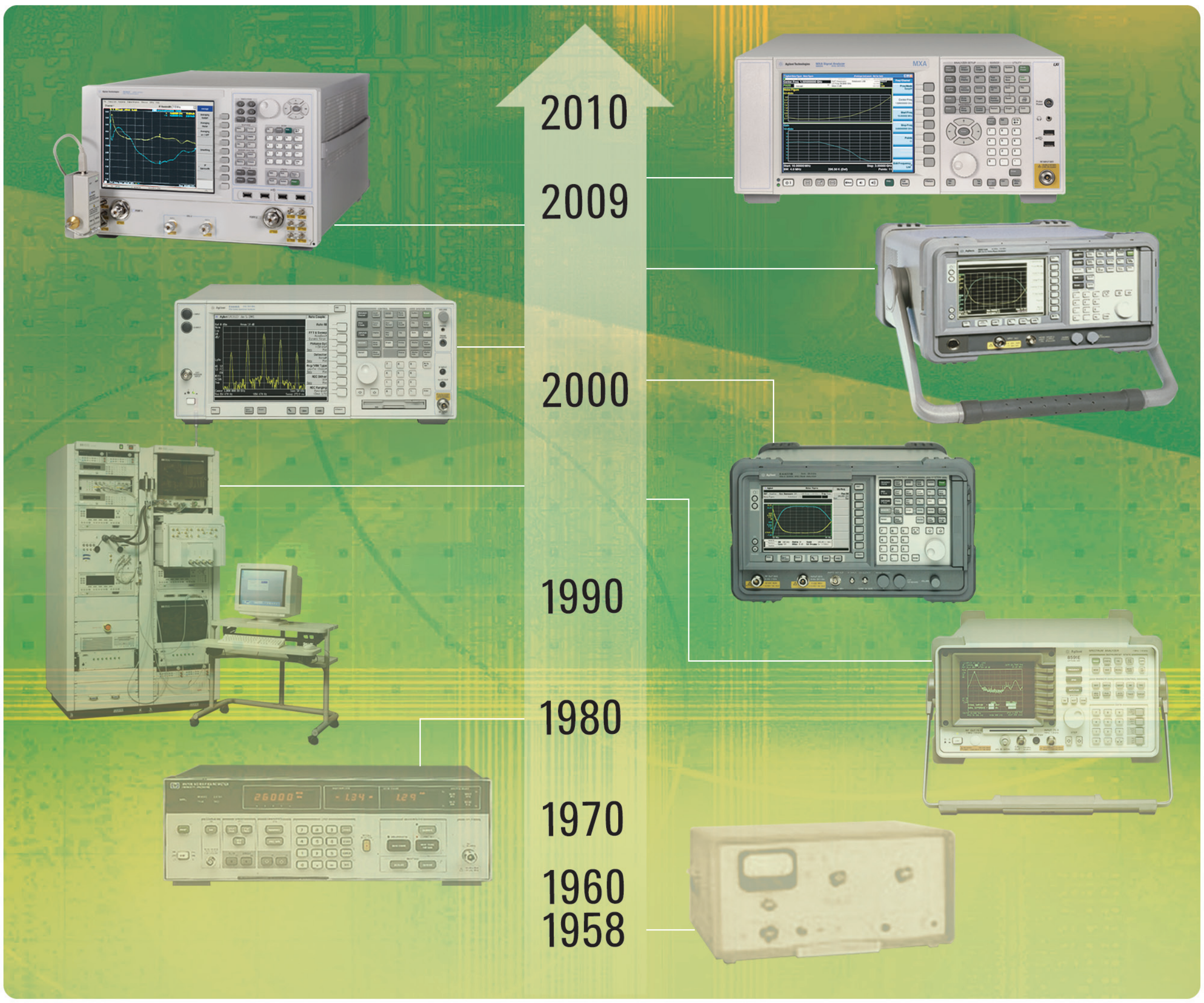
Noise Figure Selection Guide

Minimizing the Uncertainties



Flexible Solution Set That Spans a Wide Range of Needs

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Minimizing the Uncertainties of Noise Figure

Noise figure is often the key to characterizing a receiver and its ability to detect weak incoming signals in the presence of self-generated noise. The process of reducing noise figure begins with a solid understanding of the uncertainties in your components, subsystems and test setups. Quantifying those unknowns depends on flexible tools that provide accurate, reliable results.

Agilent's noise figure solution set – instruments, applications and accessories – helps you optimize test setups and identify unwanted sources of noise. We've been providing noise-figure test solutions for more than 50 years, beginning with basic noise meters and evolving into modern solutions based on spectrum, network, and noise-figure analyzers.

This selection guide begins with a brief noise figure primer on pages 3 through 9. Pages 10 through 19 present our current product lineup and will help you find the best solution for your application – whether you're designing for *good, better* or *best* performance in your device.

A list of related resources is included on page 20. Our series of seven application notes can help you develop a deeper understanding of noise figure and its inherent challenges

Find out more **www.agilent.com/find/noisefigure**

Two methods are commonly used to measure noise figure:

- *Y-factor*
- *Cold-source*

To find out more about these methods see Application Note 57-1, *Fundamentals of RF and Microwave Noise Figure Measurements,* literature number 5952-8255E.

Noise Figure Overview

Noise figure is one of the key parameters used to characterize the ability of receivers and their lower-level components to process weak signals in the presence of thermal noise. For example, when measuring low-noise amplifiers (LNAs), noise figure describes the signal-to-noise degradation that occurs due to the internally-generated noise of the active devices within an LNA.

Accurate measurements of noise figure are crucial in product design and development. Highly accurate measurements allow for better agreement between simulations and measurements, and may help uncover noise contributors that were not considered in the simulation. Before selecting the most appropriate instrument for your application, it is important to understand two key topics: how noise figure measurements are made and the uncertainties inherent in those measurements. Noise figure measurement uncertainty depends not only on the test equipment, but is also a function of the characteristics of the device under test (DUT)—for example, S-parameters and noise parameters.

There are two main methods in use today to measure noise figure. The most prevalent method is called the Y-factor or hot/cold-source technique. It uses a noise source placed at the input of the DUT, providing two levels of input noise. This method yields noise figure and scalar gain of the DUT, and is used with both spectrum and noise figure analyzer solutions. The Y-factor technique is easy to use, and it provides good measurement accuracy, especially when the noise source has a good source match and can be connected directly to the DUT.

The other method used is called the cold-source or direct-noise method. Instead of using a noise source at the DUT's input, only a known termination (usually 50 Ω) is needed. However, the cold-source method requires an independent measurement of the DUT's gain. This method works well with vector network analyzers, because vector error correction can be used to produce very accurate gain (S_{21}) measurements. When using the PNA-X signal analyzer, the combination of vector error correction and the PNA-X's unique source-correction method provides the highest noise figure measurement accuracy in the industry. The other advantage of the cold-source method is that both S-parameter and noise figure measurements can be made with a single connection to the DUT. During system calibration, a noise source is required.

DUT Uncertainty

Y-factor measurement accuracy is excellent when low-ENR noise sources, such as the N4000A or 346A, can be used, and when the noise source can be connected directly to the DUT. For many devices, this scenario provides cost-effective and accurate noise figure measurements. However, measurement uncertainty usually increases if these conditions cannot be met. The PNA-X uses more advanced error-correction methods that provide excellent accuracy in all cases, and are especially useful for in-fixture, on-wafer, or automated-test environments, where Y-factor measurement uncertainty is often significantly higher. The PNA-X is also useful when additional measurements are required, such as S-parameter, compression, and intermodulation-distortion.

When the DUT is well matched and relatively insensitive to imperfect source match (deviation from the ideal 50 Ω), then measurement uncertainty is dominated by the data-sheet specifications. In other instances, such as when measuring poorly matched devices, or when using wafer probes, imperfect system source match generates two additional sources of error that can be quite large. The first is mismatch error, which results from reflected noise power that is re-reflected by the test system, causing ripples in the measurement. The second source of error is from the interaction between the noise generated within the DUT and the source match (Γs) presented to the DUT.

Measurement Uncertainty

Several factors contribute to overall noise figure measurement uncertainty. When selecting a noise figure solution, it is important to choose the method that minimizes the main contributor to overall noise figure uncertainty.

Some of these contributions can be found on instrument data sheets – instrument uncertainty, excess noise ratio (ENR), and jitter. Others depend upon the interaction of the test system and the DUT. For example, there are two sources of error due to imperfect system source match (a deviation from the ideal 50 Ω). The first is mismatch error, which results from non-ideal power transfer between the test system and the DUT. The second source of error is from the interaction between the noise generated within the DUT and the source match (Γ_s) seen by the DUT. Figure 1 compares the noise figure measurement uncertainties produced by the Y-factor and cold-source methods. The example amplifier has a noise figure of 3 dB, gain of 15 dB, input and output match of 10 dB, and moderate noise parameters (F_{min} = 2.8 dB, Γ_{opt} = 0.27 + j0, R_n= 37.4). For the Y-factor method, the uncertainty is calculated in two different ways: with the noise source connected directly to the DUT, and with an electrical network simulating the switches and cables from an automated-test-equipment (ATE) setup placed between the noise source and the DUT (with loss correction). The PNA-X example includes the ATE network.

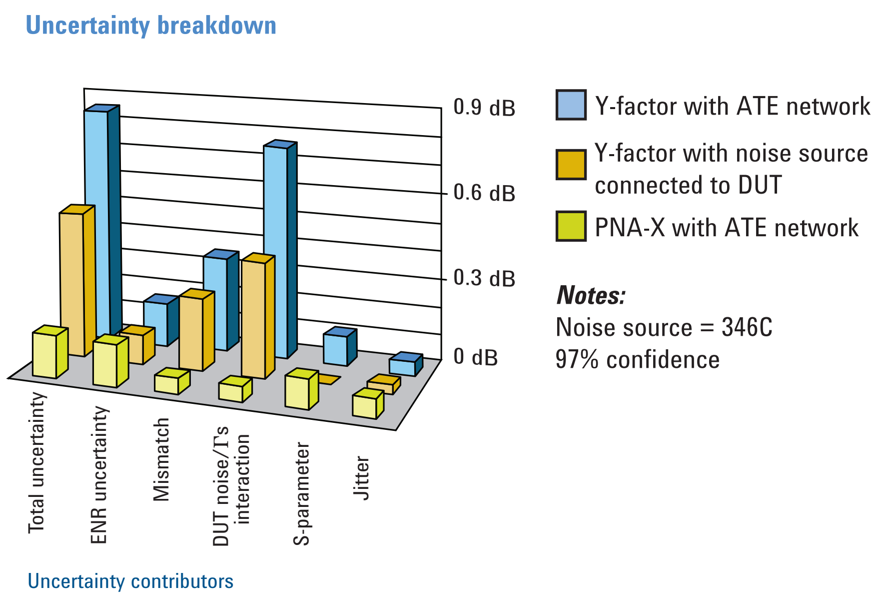


Figure 1. Breakdown of the major contributors to noise figure measurement uncertainty for the Y-factor and cold-source (with source correction) techniques.

With the Y-factor method, there are two main sources of error: mismatch between the noise source and the DUT, and the interaction of the noise generated by the DUT and the system. The simulated ATE network (inserted between the noise source and DUT) causes the errors to increase. For the PNA-X's source-corrected cold-source method, the largest source of error is the ENR uncertainty of the noise source, which affects the measurement of the PNA-X's internal noise receivers during calibration.

System Components for Noise Figure Measurements

Total or overall noise figure of a system is a result of three individual components: the instrument used to measure noise figure, the noise source used in measurements or calibration, and the DUT. The Y-factor method is the basis of most noise figure measurements. It uses a noise source to determine the internal noise in the DUT while calibrating and when making measurements. In contrast, the cold-source method uses the noise source during calibration only, as shown in Figure 2.

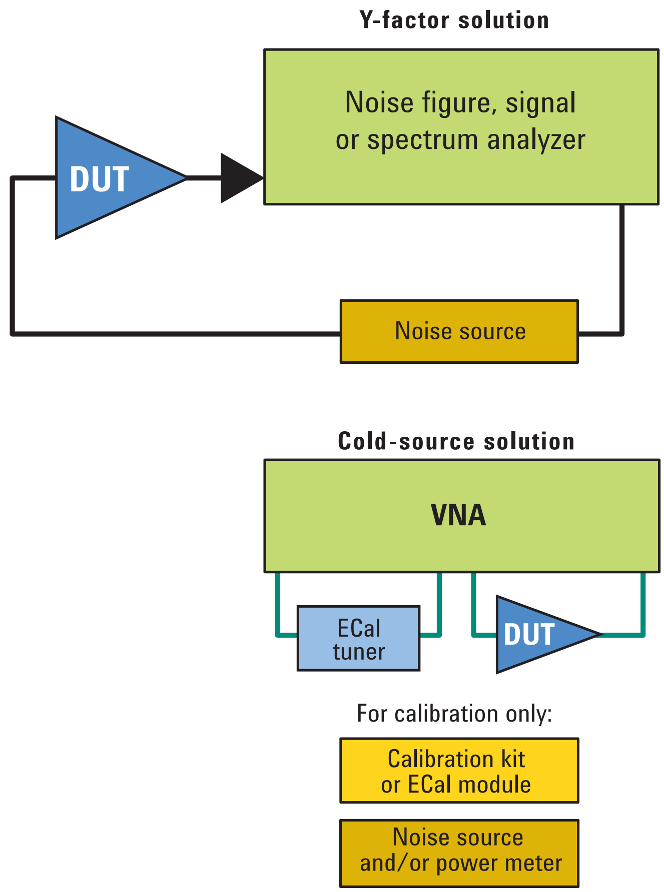


Figure 2. Basic components needed to make noise figure measurements.

Each of the components shown in Figure 2 are described in greater detail in the following sections. The Y-factor method uses either a noise figure analyzer (NFA) or a signal/spectrum analyzer with an optional noise figure measurement application. The cold-source technique uses the PNA-X network analyzer with a noise figure option to make noise figure measurements.

Agilent offers three solutions for noise figure measurements:

- *Noise figure analyzer – the only one-box solution on the market*
- *Signal/spectrum analyzers – economic solution with good performance*
- *Network analyzers – highest measurement accuracy*

Selecting an instrument

With the wide range of instruments Agilent offers for noise figure, it should be easy to find a solution that fits your requirements. Agilent offers three types of solution platforms: a dedicated noise figure analyzer, signal/spectrum analyzers, and vector network analyzers. The benefits of each are outlined below.

Noise figure analyzer (NFA): As the leader in noise figure measurement solutions, Agilent offers the industry's only one-box solution for noise figure measurements. The NFA Series is made exclusively for accurate noise figure measurements, and uses the Y-factor method. The analyzer includes a standard internal preamplifier, covers three frequency ranges (3.0, 6.7, and 26.5 GHz) and can be extended to 110 GHz with a block downconverter. The series offers low instrument noise figure and is a good compromise between a flexible signal/spectrum analyzer and the most accurate network-analyzer-based solutions.

Signal/spectrum analyzers: Adding an optional noise figure measurement application to a versatile signal or spectrum analyzer is an economical way to add noise figure capabilities. The accuracy and frequency range of this solution depends on which base instrument it is installed. Signal/spectrum analyzers use the Y-factor method to measure noise figure. Preamplification, either external or internal, often improves accuracy.

Network analyzers: If you need noise figure measurements with the highest accuracy, choose Agilent's PNA-X network analyzer with the noise figure option. This solution is based on the cold-source technique, and it allows S-parameter and noise figure measurements with a single connection to the DUT.

When selecting an instrument to meet your needs, it is first important to select one that will cover the frequency range of your DUT. Table 1 shows all of Agilent's noise figure solutions and the frequency ranges at which you can expect hard or nominal specifications, and where certain instruments are not recommended for noise figure measurements.

Specified frequency range for noise figure performance

- Not recommended
- Nominal specifications
- Hard specifications
- Hard specifications to 3.6 GHz
- Nominal specifications with block downconverters

Instrument series	200 kHz to 10 MHz	10 MHz to 3 GHz	3 to 7 GHz	7 to 26.5 GHz	26.5 to 110 GHz	Page
CXA	Nominal specifications	Hard specifications	Hard specifications	Not recommended	Not recommended	11
ESA	Not recommended	Hard specifications	Not recommended	Not recommended	Not recommended	14
EXA	Nominal specifications	Hard specifications	Hard specifications to 3.6 GHz	Not recommended	Not recommended	11
MXA	Nominal specifications	Hard specifications	Hard specifications	Hard specifications	Nominal specifications with block downconverters	11
PSA	Nominal specifications	Hard specifications	Nominal specifications	Nominal specifications	Not recommended	13
PXA	Nominal specifications	Hard specifications	Hard specifications	Hard specifications	Nominal specifications with block downconverters	11
NFA	Not recommended	Hard specifications	Hard specifications	Hard specifications	Nominal specifications with block downconverters	10
PNA-X	Not recommended	Hard specifications	Hard specifications	Hard specifications	To 50 GHz	15

Table 1. Agilent offers a wide range of instruments to cover different frequency ranges for noise figure measurements: nominal specifications are specifications based on the testing of an instrument, but are not guaranteed performance; hard specifications are specifications that are proven and guaranteed performance; and actual performance may exceed the numbers listed in the specification guide.

Measurement specifications are equally important when selecting an instrument to meet your noise figure needs. Please note that Table 2 gives the nominal specifications at 1 GHz for each instrument to enable quick, relevant comparisons. Refer to the individual specifications guide for each product for full specification information, including but not limited to hard specifications vs. nominal specifications at different frequency ranges.

Nominal specifications at 1 GHz

Y-factor instruments	Noise figure instrument uncertainty (dB)	Noise figure gain uncertainty (dB)	Instrument match	Noise figure of the instrument (dB)	Page
CXA	0.05	0.2	1.5	10.2	11
ESA	0.24	0.83	1.4	8.75	14
EXA	0.03	0.15	1.3	13	11
MXA	0.02	0.1	1.3	9.5	11
PSA	0.05	0.17	1.1	6.5	13
PXA	0.02	0.07	1.3	9.75	11
NFA	0.05	0.17	1.7	4.75	10
Cold-source instruments	**Linearity**	**S21 parameter uncertainty**	**Instrument match**	**Noise figure of the instrument (dB)**	**Page**
PNA-X	0.05	0.05	1.02	12	15

Table 2. This chart compares the different noise figure solutions at 1 GHz with nominal specifications only; for full specifications, including hard specifications, please refer to the specification guide for each instrument.

Selecting a Noise Source

When measuring noise figure, the quality of the noise source affects the accuracy and repeatability of your measurements. The ENRs of Agilent noise sources are carefully calibrated with traceability to national standards institutes in the U.S. and U.K. The output of a noise source is defined in terms of its frequency range and ENR. Nominal ENR values of 6 dB and 15 dB are commonly available. A low-ENR noise source will minimize error due to noise detector nonlinearity. This error will be smaller if the measurement is made over a smaller, and therefore more linear, range of the instrument's detector. A 6 dB noise source uses a smaller detector range than a 15 dB noise source.

Use a 6 dB noise source when:

- Measuring a device with gain that is especially sensitive to changes in the source impedance
- The DUT has a very low noise figure
- The device noise figure does not exceed 15 dB

Use a 15 dB noise source when:

- General-purpose applications to measure noise figure up to 30 dB
- User-calibrating the fullest dynamic range of an instrument before measuring high gain devices

Agilent offers three families of noise sources, each offering different frequency ranges, source matches, ENR, and connector types. The Smart Noise Source Series simplifies measurement setup by automatically downloading electronically stored calibration data to the instrument, saving valuable engineering time. The traditional 346 Series is the most cost-effective solution—these noise sources offer the widest range of frequency coverage. Lastly, Agilent offers high-frequency noise sources with waveguide interfaces for making measurements above 26.5 GHz. The noise source families above work with different instruments, summarized in Table 4.

Agilent noise sources

	Noise source	ENR	Frequency range	Page
Smart noise sources *SNS Series*	N4000A	4.6 to 6.5 dB	10 MHz to 18 GHz	16
	N4001A	14 to 16 dB	10 MHz to 18 GHz	16
	N4002A	12 to 17 dB	10 MHz to 26 GHz	16
Traditional noise sources *346 Series*	346A	5 to 7 dB	10 MHz to 18 GHz	17
	346B	14 to 16 dB	10 MHz to 18 GHz	17
	346C	12 to 17 dB	10 MHz to 26 GHz	17
	346C-K01	21 dB	1 to 50 GHz	17
High frequency noise sources *347 Series*	Q347B	6 to 13 dB	33 to 50 GHz	18
	R347B	10 to 13 dB	26.5 to 40 GHz	18

Table 3. Agilent offers three different families of noise sources to fit within a variety of budgets and test requirements.

Noise source support

Y-factor instruments	346 Series	347 Series	N4000A SNS Series	Page
CXA	▲	▲		11
ESA	▲	▲	▲	14
EXA	▲	▲	▲	11
MXA	▲	▲	▲	11
PSA	▲	▲		13
PXA	▲	▲	▲	11
NFA	▲	▲	▲	10
PNA-X	▲			15

Table 4. This table lists noise source and instrument compatibility for noise figure measurements.

Device Under Test (DUT)

Your DUT contributes to the overall noise figure uncertainty based on its individual noise figure, gain, port match, and noise parameters. In general, there are two scenarios to consider when choosing the Y-factor method. When the output noise of the DUT is well above the input noise of the analyzer, the analyzer with the best instrument uncertainty gives the most accurate results, and the MXA signal analyzer is the best choice. If the output noise of the DUT is smaller, select the NFA noise figure analyzer, which gives the lowest uncertainty. Refer to Table 2 to compare the nominal specifications of these solutions at 1 GHz.

Figure 3 shows how DUT gain affects noise figure uncertainty when using a spectrum analyzer or noise figure analyzer. This example is at 1 GHz with a 346A noise source and assumes the DUT has a 1.5 dB noise figure and 1.5:1 VSWR.

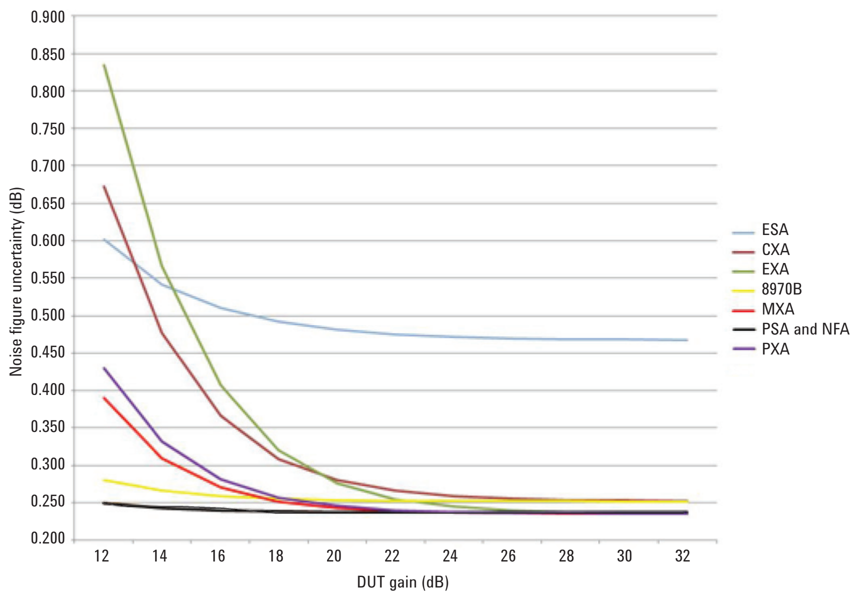


Figure 3. As the gain of a DUT decreases, Y-factor noise figure measurement uncertainty increases; below 20 dB of gain, there are significant differences between the various instrument choices.

The values in Figure 3 were computed with the noise figure uncertainty calculator and the nominal specifications at 1 GHz shown in Table 2. The uncertainty calculator can be found at **www.agilent.com/find/nfu**. The uncertainty calculator can be used for either of the following cases:

Modeling the performance of your system:

For this purpose, defaults are available for Agilent's noise figure instruments and noise sources. These defaults have typical values associated with them and can be useful for estimating the effect individual parameters have in overall uncertainty levels.

Making actual calculations of the uncertainty of your system:

You will need to obtain accurate values of all the associated parameters in question, such as match and gain. Please consult the calibration certificates of your instruments to obtain their measured uncertainty parameters.

Noise figure analyzer (NFA)
N8973A
N8974A
N8975A

The Only Dedicated Noise Figure Analyzer on the Market

The NFA Series is a family of dedicated noise figure analyzers designed to provide comprehensive characterization of your DUT. These analyzers offer the traditional benefits of a noise figure meter, plus the added features and functionality most often requested by R&D and production-test engineers and technicians. Ease-of-use features allow any engineer or technician to quickly setup measurements correctly, view those measurements in different formats, and either print the results or save them to a disk. In addition, on-screen limit lines simplify pass/fail testing. Perform your measurements to the exact specifications required with extended frequency coverage, high performance features, and selectable measurement bandwidths. Repeatable, reliable measurements provide results that you can trust. As a result, you will be able to produce more robust designs and prototypes in the lab, and achieve higher yields and throughput in manufacturing.

Features:

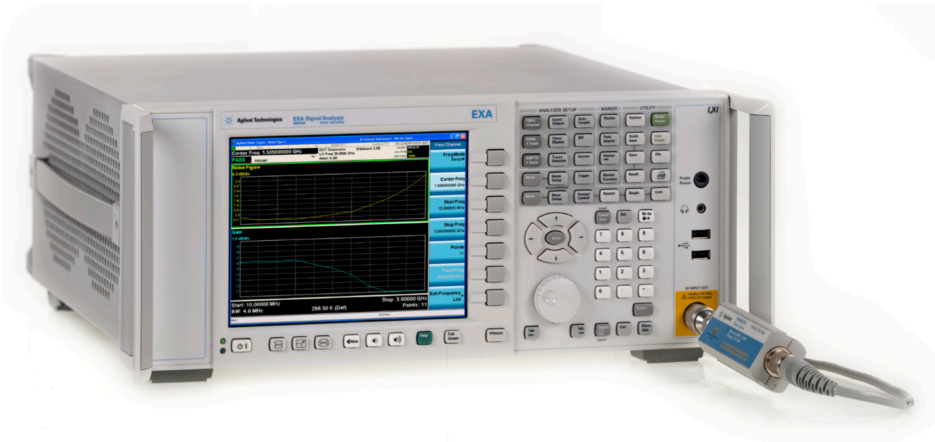
- One-box analyzers to 3, 6.7, and 26.5 GHz, with extension to 110 GHz with block downconverters
- Fully specified to 26.5 GHz with internal preamplifier
- Works with Agilent smart noise sources and 346 Series noise sources
- Internal measurement uncertainty calculator

Literature resources:

- *NFA Series Brochure*, literature number 5980-0166E
- *NFA Series Noise Figure Analyzers Configuration Guide*, literature number 5980-0163E
- *NFA Series Noise Figure Analyzers Data Sheet,* literature number 5980-0164E

X-Series signal analyzers
N9030A PXA
N9020A MXA
N9010A EXA
N9000A CXA

Noise Figure for Agilent's Fastest Signal Analyzers



Agilent's X-Series noise figure measurement application offers development engineers a simple tool to make accurate and repeatable measurements. The noise figure option utilizes the easy user interface and incredible speed of the Agilent X-Series signal analyzers. The built-in help and internal step-by-step diagrams allow new users to start making measurements instantly and save their results quickly. The W9069A for the CXA signal analyzer offers hard specifications up to 7.5 GHz. The N9069A pairs with the EXA for hard specifications up to 3.6 GHz, and the MXA or PXA for hard specifications up to 26.5 GHz. To meet these specifications, an internal preamplifier must also be ordered with the noise figure option. In addition, these noise figure applications are code-compatible with older Agilent noise figure solutions for similar measurements.

Features:

- Fully specified to 26.5 GHz with optional internal preamplifier on the MXA or PXA signal analyzer
- MXA or PXA can be used with block downconverters for noise figure measurements up to 110 GHz
- Fully specified to 3 GHz with optional internal preamplifier on the EXA signal analyzer
- Fully specified to 7.5 GHz with optional internal preamplifier on the CXA signal analyzer.
- Works with Agilent N4000A smart noise sources and 346 Series noise sources
- Internal measurement uncertainty calculator

Literature resources:

- *W9069A/N9069A Noise Figure Measurement Application, Technical Overview with Self-Guided Demonstration,* literature number 5989-6536EN

Make noise figure measurements *up to 110 GHz with either the NFA N8975A or MXA N9020A-526 or the PXA N9030A-526.*

Block Downconversion: Noise Figure Measurements Up to 110 GHz

Agilent K-Series block downconverters extend the upper frequency limit of the N8975A, N9020A-526, or N9030A-526 from 26.5 GHz up to 110 GHz. The downconverter uses an internal LO to down convert the input signal to an IF that is within the measurement range. The K-Series is offered in 13.5 GHz bands. For example, a customer that would like to do noise figure measurements to 52 GHz would order K40, K50, and K63 in order to bridge from the 26.5 GHz end frequency of their instrument to 52 GHz.

Block downconverter options

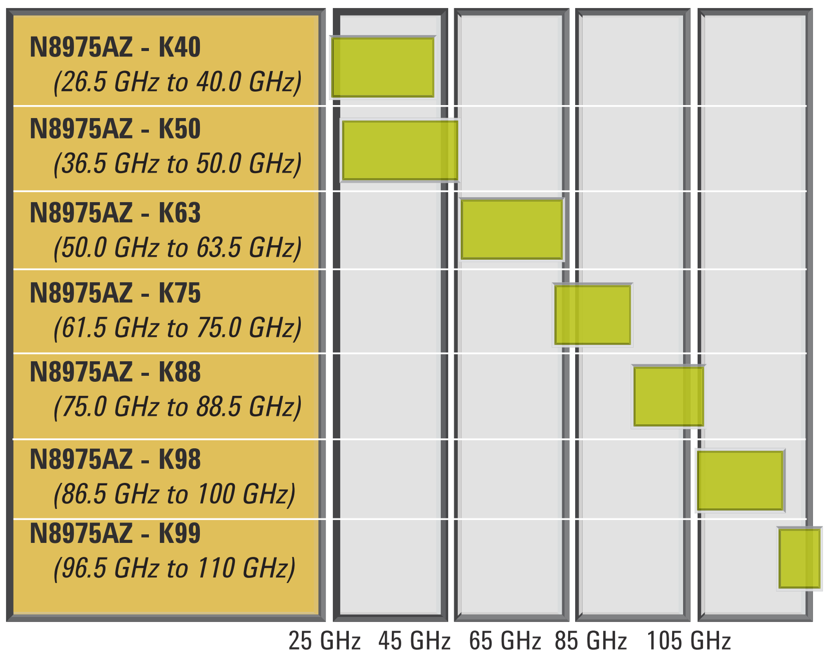
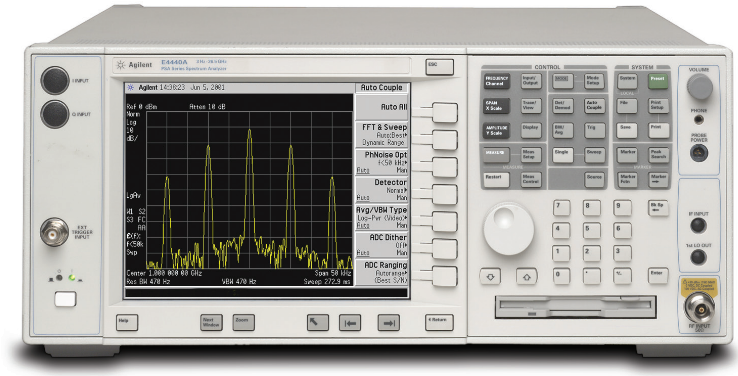


Figure 4. K-Series block downconverter frequency range chart.

PSA Series
E4446A
E4447A
E4448A
E4440A
E4443A
E4445A

High-Performance Spectrum Analyzer



The high-performance Agilent PSA Series offers the highest performance in spectrum analysis up to 50 GHz with powerful one-button measurements, a versatile feature set, and a leading-edge combination of flexibility, speed, accuracy, and dynamic range. Expand the PSA to include noise figure measurements with the noise figure measurements personality (Option 219). Use either Option 1DS or 110 to include the internal preamplifier that is needed to meet the hard specifications of the PSA noise figure personality. Although these internal preamplifiers may operate below 10 MHz or above 3 GHz, the noise figure personality gives only nominal specifications outside the 10 MHz to 3 GHz frequency range. DUT setup menus help guide you through amplifier and mixer measurements and a built-in measurement uncertainty calculator makes it easy to qualify your measurement system.

Features:

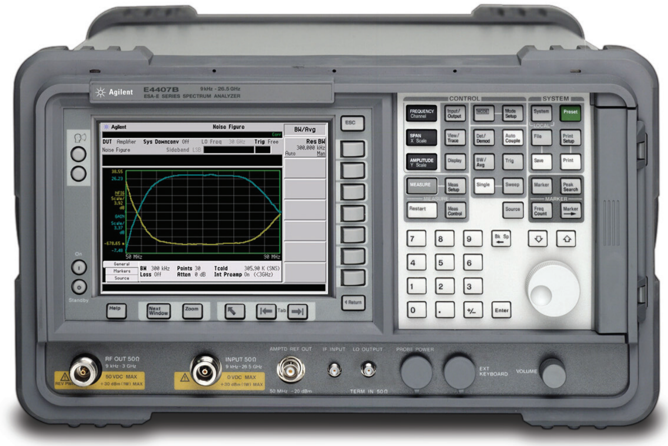
- Hard specifications between 10 MHz and 3 GHz, with internal preamplifier for best accuracy
- Nominal specifications below 10 MHz and above 3 GHz, internal preamplifier available
- Operates with the Agilent 346 Series noise sources
- Internal measurement uncertainty calculator

Literature resources:

- *PSA Series Spectrum Analyzers Noise Figure Measurement Personality,* literature number 5988-7884EN
- *PSA Series Brochure,* literature number 5980-1283E
- *PSA Series Configuration Guide,* literature number 5989-2773EN
- *PSA Series Data Sheet,* literature number 5980-1284E
- *PSA Specification Guide,* literature number E4440-90347

ESA Series
E4402B
E4404B
E4405B
E4407B

Economy-Class Spectrum Analyzer



The Agilent ESA-E Series spectrum analyzers with the noise figure measurement personality (Option 219) provides the flexibility of general-purpose spectrum analysis combined with built-in one-button noise figure measurements. This solution automates the measurement process allowing all of the required calculations for noise figure, gain, and related metrics from 10 MHz to 3 GHz to be made at the touch of a button. With other features like DUT setup menus, context-based help, and a built-in uncertainty calculator, the ESA is the solution to help you comprehensively characterize your DUT’s noise figure at a reasonable cost.

Features:

- Hard specifications between 10 MHz and 3.6 GHz, with internal preamplifier for best accuracy
- Works with Agilent N4000A smart noise sources and 346 Series noise sources
- Internal measurement uncertainty calculator

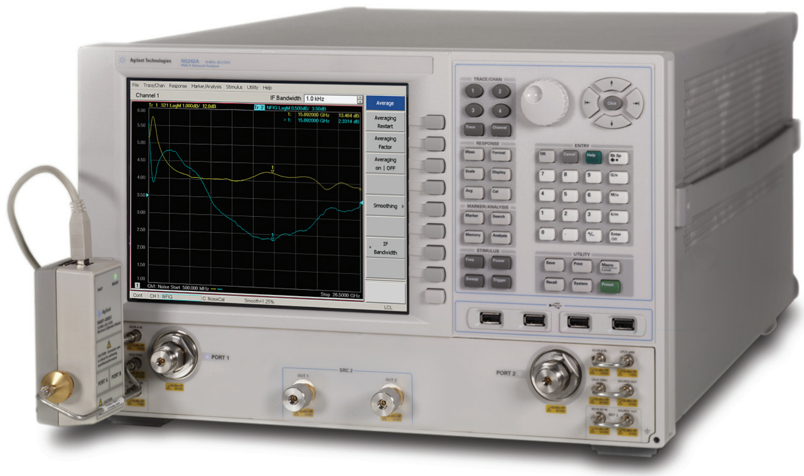
Literature resources:

- *ESA-E Series Spectrum Analyzers Noise Figure Measurements*, literature number 5989-0215EN
- *ESA-E Series Spectrum Analyzers Brochure*, literature number 5968-3278E
- *ESA Spectrum Analyzer Configuration Guide*, literature number 5968-3412E
- *ESA Series Spectrum Analyzers Data Sheet*, literature number 5968-3386E
- *ESA Signal Analyzer Specifications Guide,* literature number E4401-90490

PNA-X microwave network analzyer

N5241A
N5242A
N5244A
N5245A

Noise Figure Measurements with the Highest Accuracy in the Industry



The Agilent PNA-X is the industry standard for high-performance microwave network analysis from 10 MHz to 50 GHz. This 2- or 4-port network analyzer offers a flexible, single-connection solution for S-parameter, noise figure, intermodulation distortion, compression, and pulsed-RF measurements. Agilent's unique source-corrected noise figure method (Options 028, 029, and H29) builds on the integrated, vector-error-corrected cold-source technique pioneered by the Agilent 8510 network analyzer. Using the PNA-X and an Agilent ECal module configured as an impedance tuner, mismatch and noise-parameter errors due to imperfect system source match are removed, greatly improving the accuracy of the cold-source technique. This approach surpasses the accuracy provided by today's Y-factor-based noise figure analyzers or spectrum analyzer solutions. With this option built directly into the Agilent PNA-X, the solution provides a complete single-connection, multiple-measurement package for R&D and manufacturing engineers developing and testing low-noise transistors, amplifiers, and transmit/receive (T/R) modules.

Features:

- Unique measurement technique provides the highest accuracy of any noise figure solution on the market
- Measure S-parameters, noise figure, compression, and intermodulation distortion with a single connection to the DUT
- Typically four to ten times faster than NFA (using 51 or 201 points)
- Works with coaxial, in-fixture, or on-wafer devices
- Hard specifications from 10 MHz to 50 GHz

Literature resources:

- *PNA Series Brochure, literature number 5990-4592EN*
- *PNA Series Configuration Guide, literature number 5989-7606EN*
- *PNA-X Data Sheet, literature number N5242-90007*
- *High Accuracy Noise Figure Measurements Using the PNA-X Series Network Analyzer application note, literature number 5990-5800EN*

SNS series smart noise sources
N4000A
N4001A
N4002A

Automatically Downloads ENR Tables To Your Instrument

The SNS Series noise sources can be used in conjunction with the X-Series signal analyzers, dedicated noise figure analyzers (NFA), and ESA spectrum analyzers. The SNS noise sources replicate the ENR output and frequency coverage of the traditional 346 Series noise sources; however, they have added benefits. The ENR data is stored in an EPROM and is automatically downloaded to the instrument, saving the need to manually enter the values into the calibration table at each cardinal frequency point. Another key benefit is that a thermistor is built into the noise source to continually update the analyzer with the correct temperature, yielding more accurate measurements due to automatic temperature compensation/correction.

Features:

- Electronic storage of ENR calibration data decreases the opportunity for user error
- Automatic download of ENR data to the instrument speeds overall set-up time
- Temperature compensation improves measurement accuracy leading to tighter specifications

Literature resources:

- *SNS Technical Overview,* literature number 5988-0081EN

346 Series traditional noise sources
346A
346B
346C

Agilent's Most Popular Noise Source Series

The traditional and cost-effective noise source is the 346 Series, which operates with the full range of Agilent noise figure solutions. The 346 Series is categorized by its frequency coverage as well as ENR. Some active devices are sensitive to port match. They exhibit different noise figure values dependent on the source impedance. Noise sources will change their port impedance (SWR) as they are switched from T Hot to T Cold. Noise sources like the 346A have output circuitry that will minimize the impedance changes.

Features:

- Low SWR for reducing noise figure measurement uncertainty
- Individually calibrated ENR values at specific frequencies
- Calibration supplied on floppy disk for easy loading into NFA Series noise figure analyzers

Literature resources:

- *Agilent 346A/B/C Noise Sources: 10 MHz to 26.5 GHz,* literature number 5953-6452B

347 Series high frequency noise sources
R347B
Q347B

Noise Source Solution for Millimeter-Wave Devices

These waveguide noise sources allow you to make accurate and convenient noise figure measurements on millimeter-wave devices. The 347 Series provides extremely precise broadband noise at the input of the system or component under test. The noise figure meter then processes the ON/OFF ratio of noise power present in the system IF, and provides an accurate reading of noise figure and gain. These noise sources have remarkable ENR stability over time, which allows longer recalibration cycles and more accurate noise figure measurements.

Features:

- Performance and reliability at millimeter-wave frequencies
- Excellent ENR stability over time
- Low SWR

Web resources:

- **www.agilent.com/find/SNS** (select 347 Noise Source Family)

Noise source test set
N2002A

Fast, Repeatable Calibrations with Confidence

The Agilent N2002A noise source test set is a stand-alone instrument that, as part of a calibration system, enables fast, repeatable calibrations with minimal levels of uncertainty. It is needed when making ENR tests on a noise source. This low-cost, easy-to-use test set ensures accurate calibration results, increasing measurement confidence and allowing the development of DUTs with tighter specifications. The N2002A noise source test set operates over a frequency range of 10.0 MHz to 26.5 GHz.

Features:

- Reduces noise figure uncertainty to ensure accurate and repeatable results
- Results traceable to national standards
- Full calibration of all Agilent SNS and 346 noise sources
- Manual control or remote operations using GPIB

Literature resources:

- *N2002A Noise Source Test Set User's Guide,* literature number N2002-90001
- *Using the Agilent N8975A Noise Figure Analyzer and the N2002A Noise Source Test Set,* literature number 5988-7229EN

Additional Resources

Literature

- *10 Hints for Making Successful Noise Figure Measurements (AN 57-3),* literature number 5980-0288E
- *Fundamentals of RF and Microwave Noise Figure Measurement (AN 57-1),* literature number 5952-8255E
- *Noise Figure Measurement Accuracy: The Y-Factor Method (AN 57-2),* literature number 5952-3760E
- *Noise Figure Measurements of Frequency Converting Devices (AN 1487),* literature number 5989-0400EN
- *Non-Zero Noise Figure After Calibration (AN 1484),* literature number 5989-0270EN
- *Practical Noise Figure Measurement and Analysis for Low-Noise Amplifier Designs (AN 1354),* literature number 5980-1916E
- *High-Accuracy Noise Figure Measurements Using the PNA-X Series Network Analyzer (AN 1408-20),* literature number 5990-5800EN

Web

- Noise figure solutions:
  www.agilent.com/find/noisefigure
- Hints for Making Better Noise Figure Measurements - video series
  www.agilent.com/find/noisefigurevideos

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