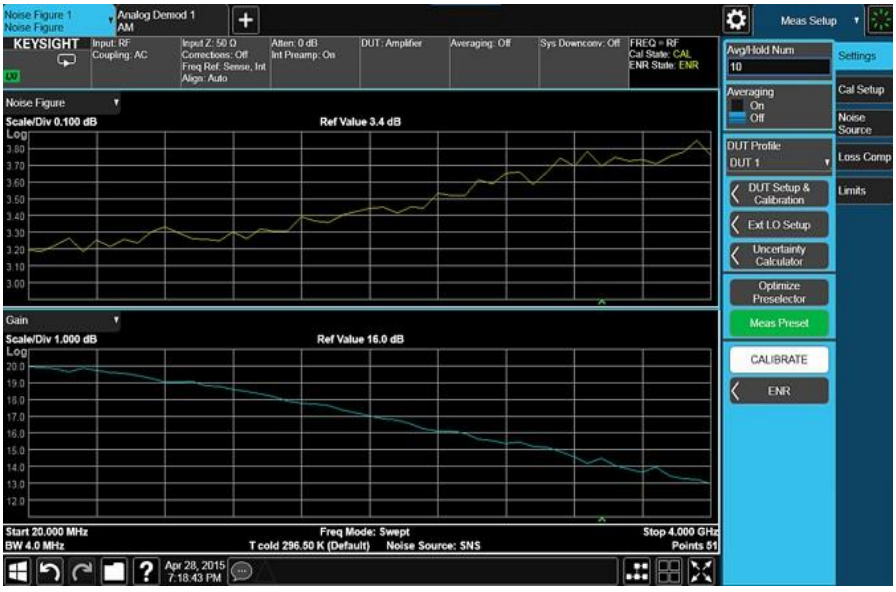
Noise Figure Measurement Application

Multi-Touch UI N9069EM0E / E9069EM0E / W9069EM0E [1]

Key Features

- Characterize noise figure and gain of connectorized devices and system blocks with graph, meter, and table layouts
- Measure noise figure/factor, gain, Y-factor, effective temperature and hot/cold power density
- Estimate the overall noise figure uncertainty using the built-in uncertainty calculator
- Provide fully-specified measurements with optional internal preamp in instrument; improved specifications with external USB preamps U7227/8 Series
- Speed up multi-DUT measurements with multi-DUT calibration and measurement profiles
- Extend the frequency range to 50 GHz above (such as V/E/W/D/H-Band) with Keysight or third party noise source, external down-converter, and external LO source combination solution
- Support multi-touch front panel user interface or SCPI remote interface
- Flexible licensing provides the option of using perpetual or time-based licenses with one or multiple signal analyzers



1. Keysight supports tiered application models with N-models for UXA/PXA/PXE/NFA-B/PXI VSA, E-models for MXA/EXA/MXE/VXT, and W-models for CXA. The higher tiered application models can run at the lower platforms, which means N-models can run on all platforms, E-models can run on MXA/EXA/MXE/VXT and CXA, and W-models can only run on CXA

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Introduction

Noise figure is one of the fundamental parameters that differentiates one system, amplifier, or transistor from another. To minimize the problems resulting from noise generated in receiver systems, engineers can either make a weak signal stronger, or reduce the noise of that system or its individual components. The Keysight Technologies, Inc. N9069EM0E noise figure measurement application offers development engineers a simple tool to make accurate and repeatable noise figure measurements. The speed of this application also allows manufacturing engineers to rapidly measure any one of the following in their test racks:

- Noise figure/factor
- Gain
- Effective temperature
- Y-factor
- Hot/cold power density

The noise figure application utilizes the Y-factor method for calculating noise figure. By using a noise source, an X-Series signal analyzer can quickly determine the noise of the device under test. This method is very simple, as it utilizes a ratio of two noise power levels: one measured with the noise source ON and the other with the noise source OFF.

Preamps are available to reduce the uncertainty of Y-factor noise figure measurements. With an optional preamp installed in an X-Series signal analyzer or standard with N8973/N8974/N8975/N8976B NFA X-Series, you can obtain better noise figure measurements. NFA X-Series specifications are not included in this document. For those specifications, please visit www.keysight.com/find/NFA_X-series_specifications.

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.

Make fast, accurate noise figure measurements with NFA

Performing accurate noise figure measurements start with a solid understanding of the uncertainty contributors - your components, subsystems and test equipment. The NFA X-Series noise figure analyzers are the simple way to make fast, accurate and repeatable noise figure measurements up to 40 GHz. With built-in expertise, ease of use features and a best-in-class USB preamplifier, our NFA's help you easily set up complex measurements - providing you with repeatable and reliable results while minimizing the overall uncertainty for your noise figure measurement challenges.

Top Features

Noise figure and gain measurements for amplifier and converters

The N9069EM0E noise figure measurement application provides accurate noise figure and gain results for the DUT, which can be amplifiers or converters (including multi-stage converters). The noise figure and gain results are shown versus frequencies.

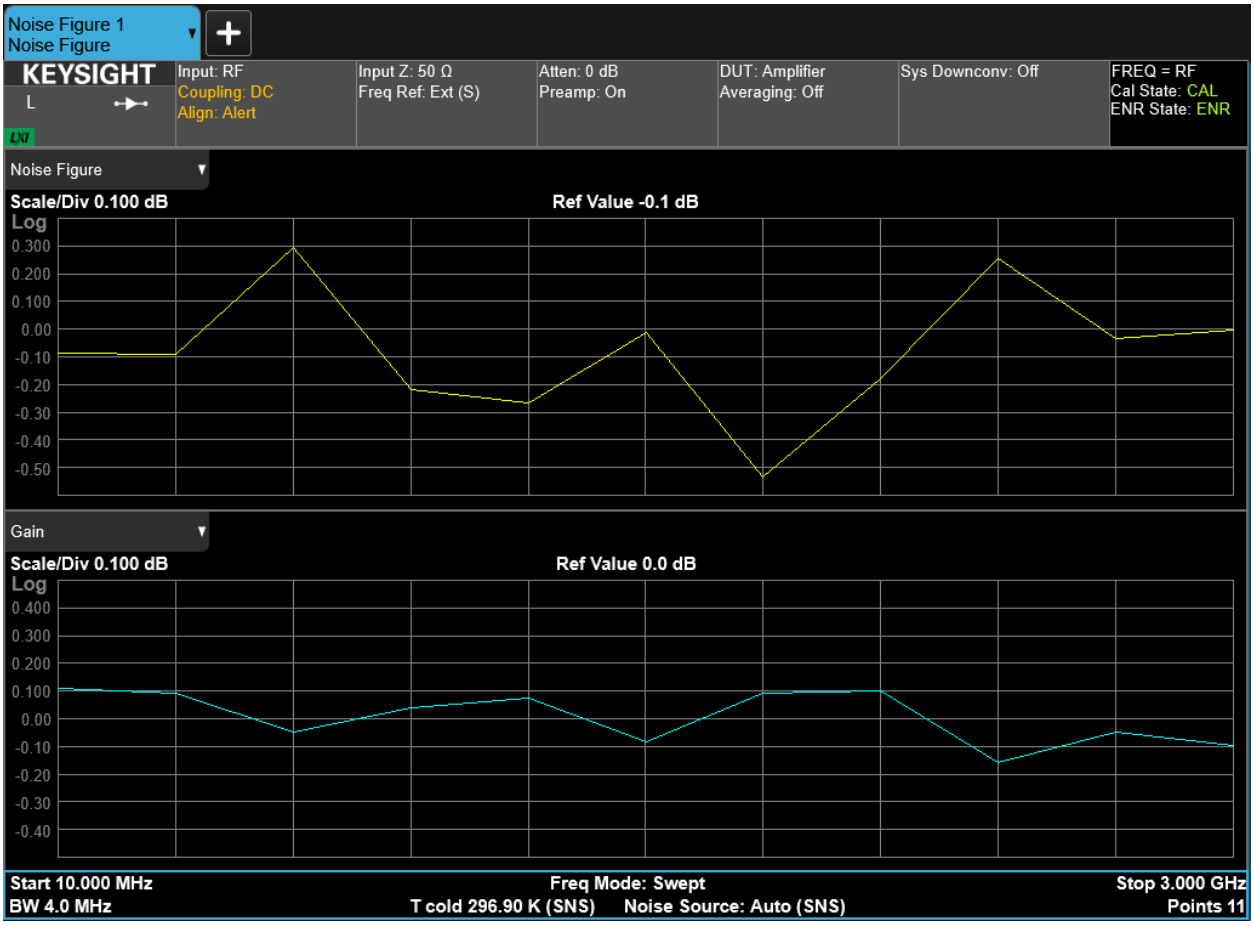


Figure 1. Noise figure and gain measurements

Multi-DUT calibration and measurement profiles

Use this feature to speed up your multi-DUT measurements. It enables you to set up measurement profiles for up to 12 DUTs, calibrate for each profile continuously, and make noise figure measurements on each DUT with the corresponding profile.

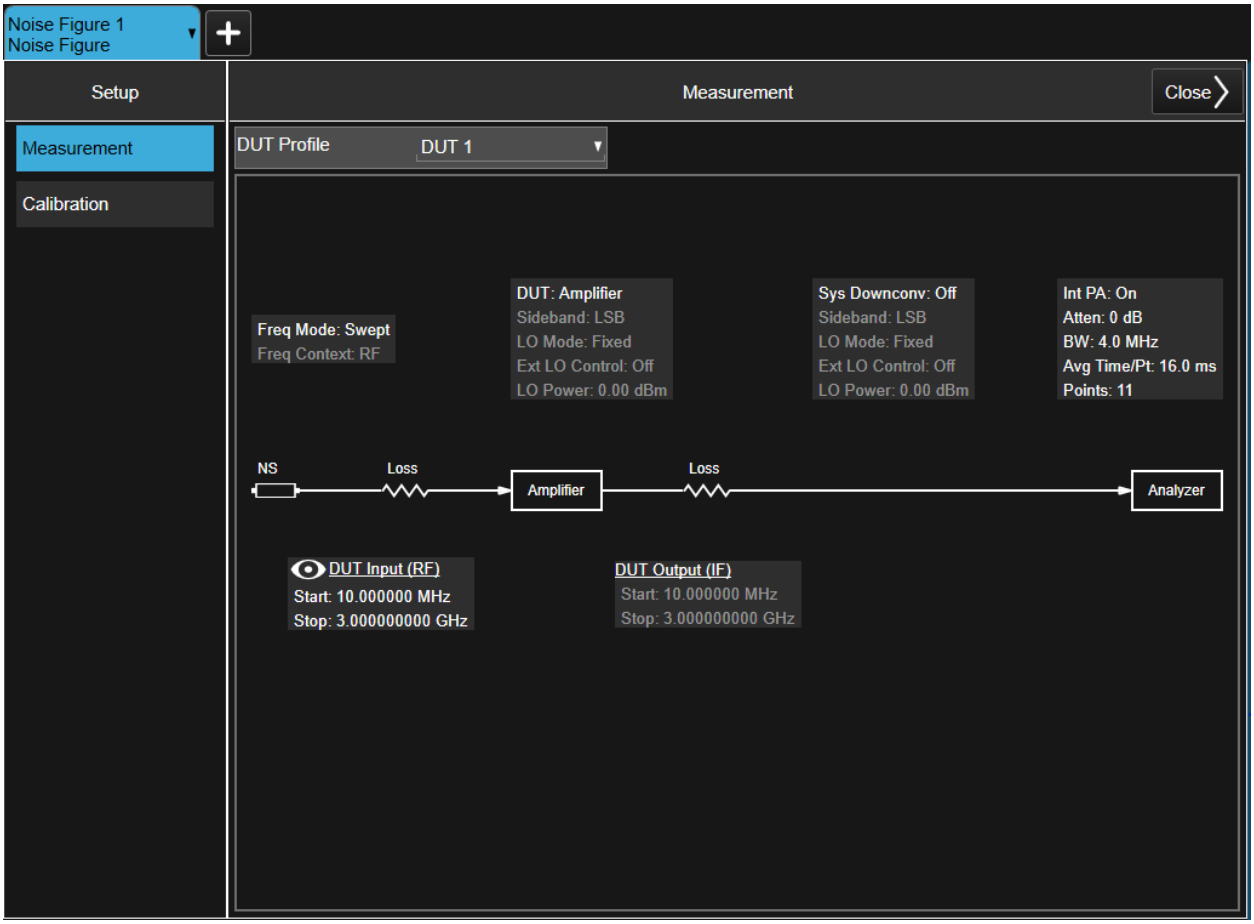
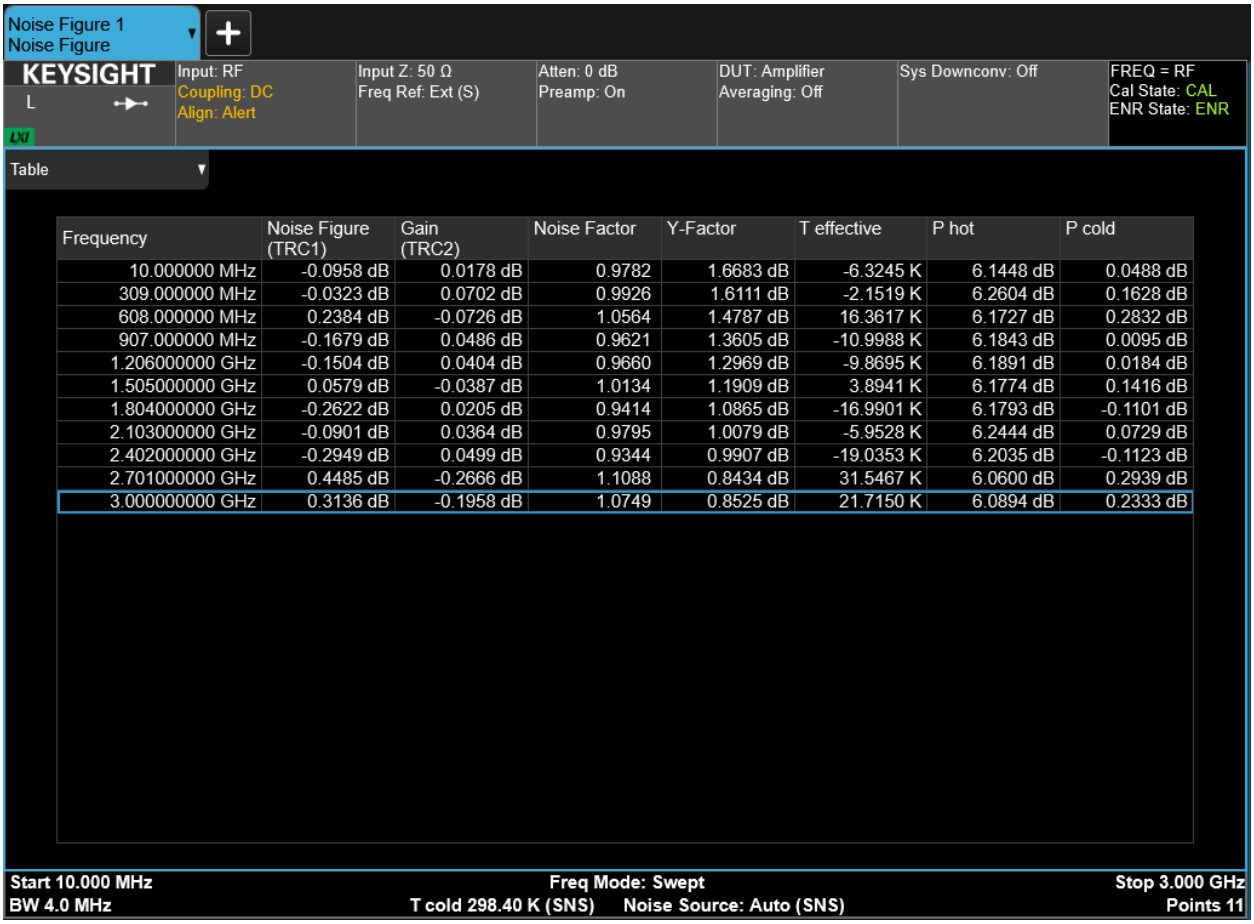


Figure 2. Measurement profile

Simultaneous display of multi-results in table format or meter view

View multiple results of the DUT simultaneously in the table or meter layout. Results include noise figure, gain, noise factor, Y-Factor, T-Effective, P hot, and P cold.



Frequency	Noise Figure (TRC1)	Gain (TRC2)	Noise Factor	Y-Factor	T effective	P hot	P cold
10.000000 MHz	-0.0958 dB	0.0178 dB	0.9782	1.6683 dB	-6.3245 K	6.1448 dB	0.0488 dB
309.000000 MHz	-0.0323 dB	0.0702 dB	0.9926	1.6111 dB	-2.1519 K	6.2604 dB	0.1628 dB
608.000000 MHz	0.2384 dB	-0.0726 dB	1.0564	1.4787 dB	16.3617 K	6.1727 dB	0.2832 dB
907.000000 MHz	-0.1679 dB	0.0486 dB	0.9621	1.3605 dB	-10.9988 K	6.1843 dB	0.0095 dB
1.206000000 GHz	-0.1504 dB	0.0404 dB	0.9660	1.2969 dB	-9.8695 K	6.1891 dB	0.0184 dB
1.505000000 GHz	0.0579 dB	-0.0387 dB	1.0134	1.1909 dB	3.8941 K	6.1774 dB	0.1416 dB
1.804000000 GHz	-0.2622 dB	0.0205 dB	0.9414	1.0865 dB	-16.9901 K	6.1793 dB	-0.1101 dB
2.103000000 GHz	-0.0901 dB	0.0364 dB	0.9795	1.0079 dB	-5.9528 K	6.2444 dB	0.0729 dB
2.402000000 GHz	-0.2949 dB	0.0499 dB	0.9344	0.9907 dB	-19.0353 K	6.2035 dB	-0.1123 dB
2.701000000 GHz	0.4485 dB	-0.2666 dB	1.1088	0.8434 dB	31.5467 K	6.0600 dB	0.2939 dB
3.000000000 GHz	0.3136 dB	-0.1958 dB	1.0749	0.8525 dB	21.7150 K	6.0894 dB	0.2333 dB

Figure 3. Measurement results in table format

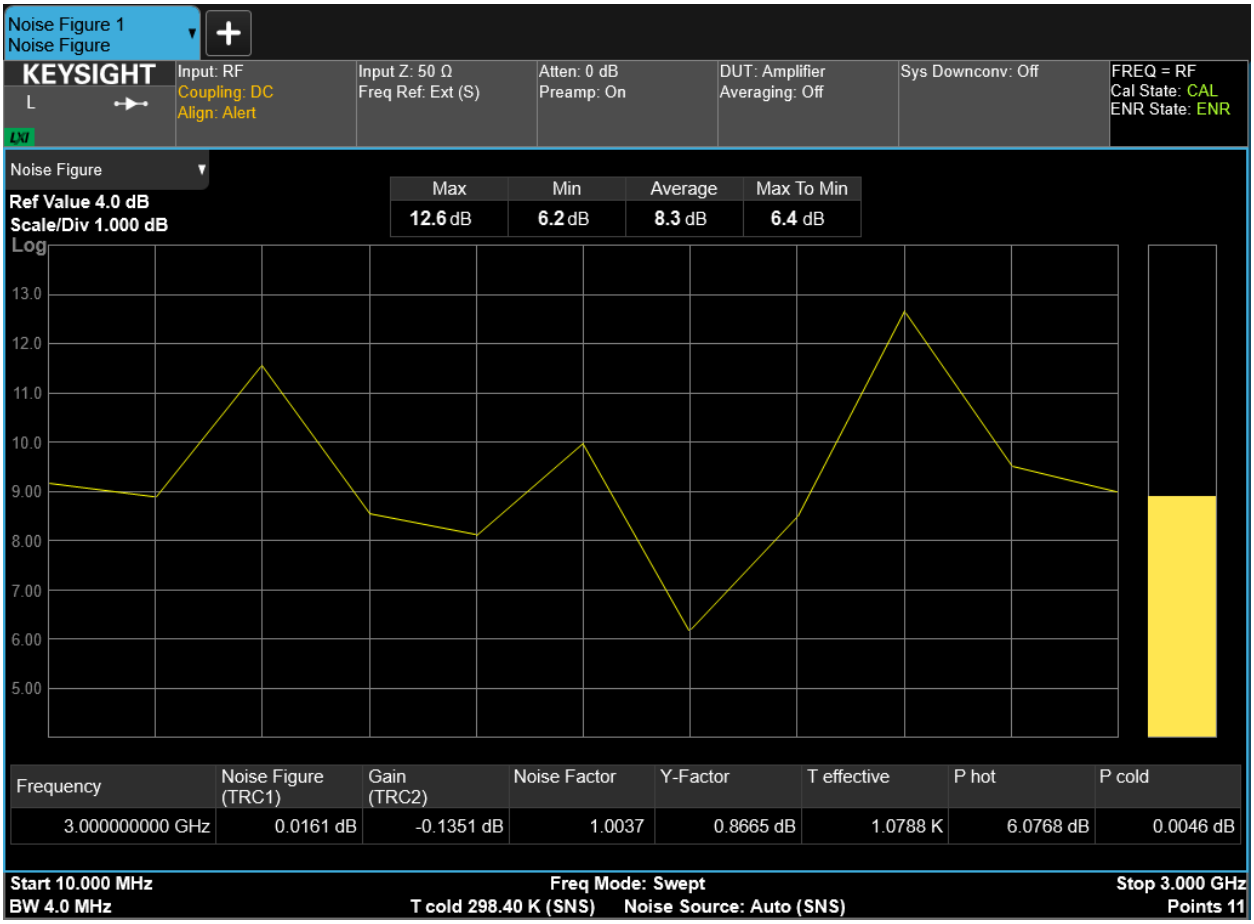


Figure 4. Measurement results in meter view

Built-in uncertainty calculator

Use the built-in uncertainty calculator to calculate the measurement uncertainty for the current measurement. It simplifies the process of calculating measurement uncertainty by importing the SNS ENR and the USB preamplifier data (if connected to the analyzer) as well as the instrument data automatically.

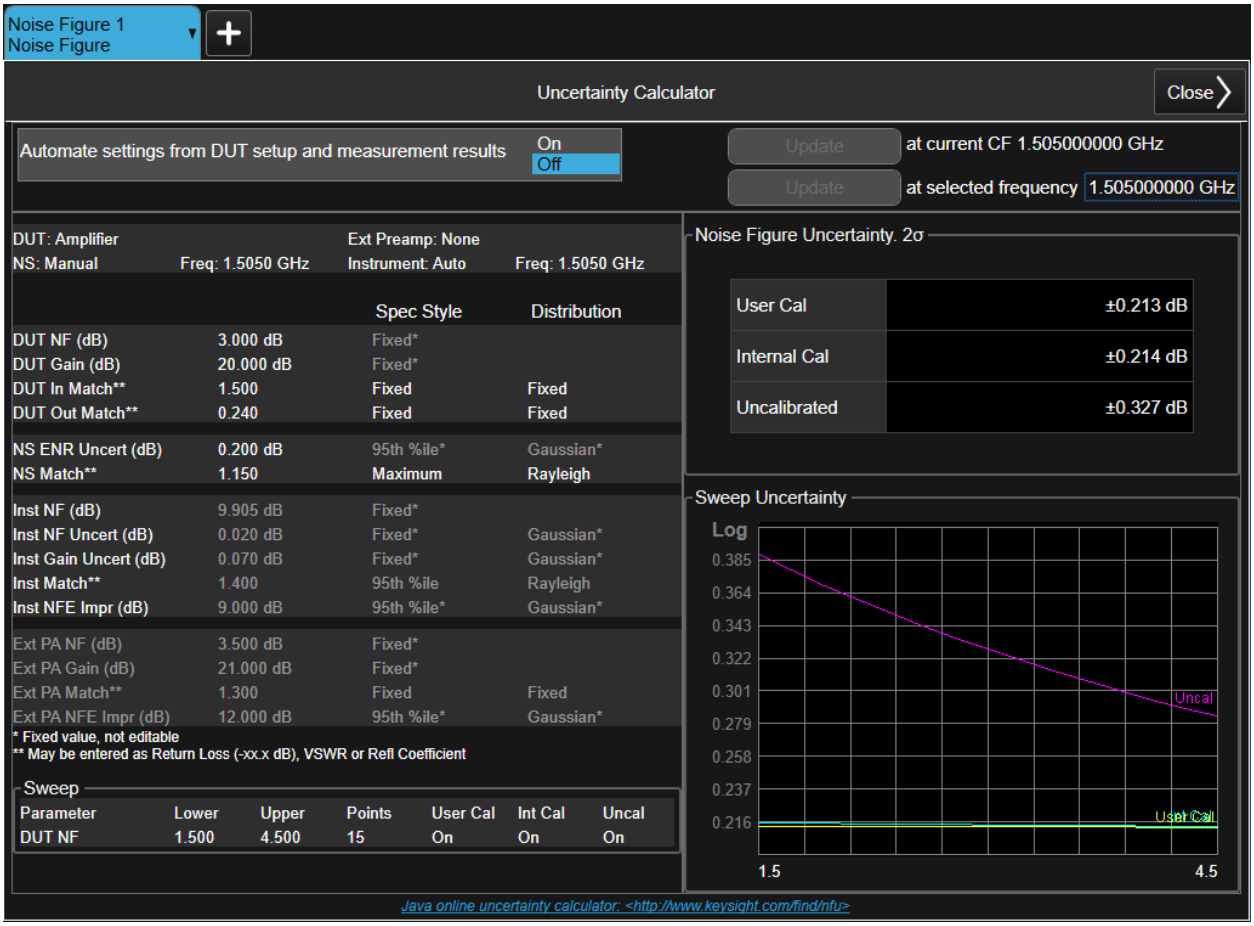


Figure 5. Built-in uncertainty calculator

Noise figure measurements above 50 GHz

In the early 6G research, V/E/W/D/H-Band frequency bands have been explored for early research prototyping and system performance validation. Noise Figure measurement in these bands is essential to verify new designs and demonstrate the device under test (DUT) meets specifications.

Keysight noise figure measurement solution above 50 GHz is introduced, consisting of Keysight X-Series signal analyzer with N9069EM0E noise figure measurement application, external downconverter, noise source, and Keysight microwave analog signal generator as local oscillator (LO). A typical block diagram is shown below.

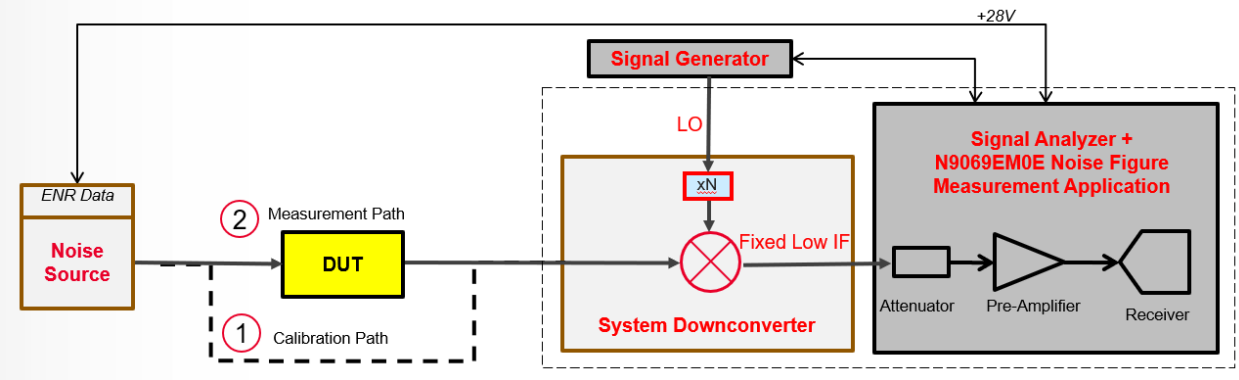


Figure 6. Noise figure measurement solution above 50 GHz

The downconverter uses an internal LO to down convert the input signal to an IF that is within the signal analyzer range. Currently, Keysight noise figure measurement solution covers V-band, E-band, W-band, D-band and H-band frequency ranges from 50 to 330 GHz.

Measurement procedure

The noise figure measurement procedure steps are:

1. Set up the noise figure measurement system connections (without DUT, connection ①).
2. Load ENR table for noise source and configurate parameters.
3. Calibrate the noise figure measurement system.
4. Connect the DUT between noise source and external downconverter (connection ②), and then perform the noise figure measurement.

The operation is automatically controlled and performed by N9069EM0E noise figure measurement application. Once the calibration is done, you can make one-button noise figure measurements and get test results of noise figure and gain, to quickly evaluate your DUT performance.

Hardware configuration for V/E/W/D/H-Band

This section gives recommended hardware configuration for your test in V/E/W/D/H-Band, including noise source, downconverter and signal generator. For more information, refer to Hardware Configuration section in this document. (Note: Export restrictions apply to frequencies > 90 GHz)

Typical noise figure measurement setup for H-Band is shown below as an example.

Figure 7. Noise figure measurement setup for H-band

Note: N9029AV03 is discontinued and replaced by N9029BV-W03.

X-Series Signal analyzer

Signal analyzers in following table can work with Keysight noise figure measurement solution in V/E/W/D/H-Band. They are categorized by frequency coverage.

Band	Frequency range	Signal analyzer [1, 2] model number	Downconverter
V-Band	50 GHz to 75 GHz	UXA N9042B	V3050A
		UXA N9040B, N9041B	N9029BW-W15
		PXA N9030B, N9032B	
		MXA N9020B, N9021B	
		EXA N9010B	
		CXA N9000B	N9029BV-W15
E-Band	60 GHz to 90 GHz	UXA N9042B	V3050A
		UXA N9040B, N9041B	N9029BV-W12
		PXA N9030B, N9032B	
		MXA N9020B, N9021B	
		EXA N9010B	
		CXA N9000B	N9029BV-W12
W-Band	75 GHz to 110 GHz	UXA N9040B, N9041B, N9042B	N9029BV-W10
		PXA N9030B, N9032B	
		MXA N9020B, N9021B	
		EXA N9010B	
		CXA N9000B	N9029BV-W10
D-Band	110 GHz to 170 GHz	UXA N9040B, N9041B, N9042B	N9029BV-W06
		PXA N9030B, N9032B	
		MXA N9020B, N9021B	
		EXA N9010B	
		CXA N9000B	N9029BV-W06
H-Band	220 GHz to 330 GHz	UXA N9040B, N9041B, N9042B	N9029BV-W03
		PXA N9030B, N9032B	
		MXA N9020B, N9021B	
		EXA N9010B	
		CXA N9000B	N9029BV-W03

1. UXA N9042B works with V3050A module and requires Option EXW.
2. UXA, PXA, MXA or EXA work with N9029BV modules and require Option EXW.

Noise source

Noise sources in following table can work with Keysight noise figure measurement solution in V/E/W/D/H-Band. They are categorized by frequency coverage. The excess noise ratio (ENR) for each model is also listed.

Band	Frequency range	Noise source [1]	Manufacture part number	ENR
V-Band	50 GHz to 75 GHz	U1833D USB Smart Noise Source (500 MHz to 60 GHz)	Keysight U1833D	10 dB nominal
		N9029AV15-NSM[4]	VDI WR15NS	17 dB typical
		NC5000A Series	Noisecom NC5115A [2]	15.5 dB typical
E-Band	60 GHz to 90 GHz	NC5000A Series	Noisecom NC5112A [2]	15 dB typical
		N9029AV12-NSM[4]	VDI WR12NS [3]	15 dB typical
W-Band	75 GHz to 110 GHz	NC5000A Series	Noisecom NC5110A [2]	15 dB typical
		N9029AV10-NSM[4]	VDI WR10NS [3]	15 dB typical
D-Band	110 GHz to 170 GHz	N9029AV06-NSM[4]	VDI WR6.5NS [3]	10 dB typical
H-Band	220 GHz to 330 GHz	N9029AV03-NSM[4]	VDI WR3.4NS [3]	13 dB typical

1. Noise sources require necessary isolators which are not covered in this document.
2. The Noisecom sources are manufactured by Noisecom. For more information, see https://www.noisecom.com/
3. The VDI sources are manufactured by Virginia Diodes, Inc. For more information, see https://www.vadiodes.com/.
4. Order the N9029AV03/06/10/12/15-NSM through N9029AV99 Accessories for Millimeter Wave Frequency Extension Modules

Downconverter

When the DUT has output frequencies above the range of the signal analyzer, a downconverter is required. The downconverter modules provide broadband frequency down-conversion. The N9029AVxx modules can be used with a signal generator (as LO) to down-convert V/E/W/D/H-Band signals to lower frequencies and feed the down-converted signals into the signal analyzer RF input to perform noise figure measurements.

Band	Frequency range	Downconverter	Manufacture part number
V-Band	50 GHz to 75 GHz	V3050A [1]	Keysight V3050A
		N9029AV15	VDI WR15SAX[2]
		N9069BV-W15	VDI WR15 Mini SAX
E-Band	60 GHz to 90 GHz	N9029AV12	VDI WR12SAX [2]
		N9029BV-W12	VDI WR12 Mini SAX
W-Band	75 GHz to 110 GHz	N9029AV10	VDI WR10SAX [2]
		N9029BV-W10	VDI WR10 Mini SAX
D-Band	110 GHz to 170 GHz	N9029AV06	VDI WR6.5SAX [2]
		N9029BV-W06	VDI WR6.5 Mini SAX
H-Band	220 GHz to 330 GHz	N9029AV03	VDI WR3.4SAX [2]
		N9029BV-W03	VDI WR3.4 Mini SAX

1. Keysight V3050A module works with Keysight UXA N9042B and does not require an external signal generator as LO.
2. VDI recommends the use of a waveguide isolator between the DUT output and the RF Input Port of VDI SAX Module to improve impedance match and reduce possible standing waves. The VDI modules are manufactured by Virginia Diodes, Inc. For more information, see https://www.vadiodes.com/en/products/spectrum-analyzer

External LO

Keysight microwave analog signal generator can work with the downconverter as external LO. The N9069EM0E noise figure measurement application will control the external LO through LAN.

Band	Frequency range	Signal generator [1] (as LO)	External downconverter
V-Band	50 GHz to 75 GHz	NA	V3050A
		N5183B MXG, E8257D PSG	N9029BV15
E-Band	60 GHz to 90 GHz	N5183B MXG, E8257D PSG	N9029BV12
W-Band	75 GHz to 110 GHz	N5183B MXG, E8257D PSG	N9029BV10
D-Band	110 GHz to 170 GHz	N5183B MXG, E8257D PSG	N9029BV06
H-Band	220 GHz to 330 GHz	N5183B MXG, E8257D PSG	N9029BV03

1. Other signal generators may be used but will need to communicate and be controlled by the Keysight Spectrum Analyzer. The signal generator must be able to drive the LO Input Port of the VDI SAX Module across the required frequency range and power level.

Key Specifications

Definitions

- Specifications describe the performance of parameters covered by the product warranty.
- 95th percentile values indicate the breadth of the population (≈2) 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.

Analyzer noise figure is computed from the specified DANL. See specifications on following pages for further explanation.

Noise figure for the combination of USB preamp and analyzer is

$$NF_{sys} = 10 * Log\ (F_{preamp} + (F_{analyzer} - 1)/G_{preamp})$$

The noise figure and gain of the preamp are specified and warranted.

Analyzer VSWR is characterized to the 95th percentile but not measured and warranted. USB preamp VSWR is measured and warranted and becomes the input VSWR of the measurement system when used.

Instrument uncertainty is defined for gain measurements as uncertainty due to relative amplitude uncertainties encountered in the analyzer when making the measurements required for the gain computation.

The noise figure measurement application is not specified for use below 10 MHz. Instrument uncertainty will nominally be the same as the 10 MHz to 3.6 GHz specifications; however, performance is not warranted. Instrument uncertainty for gain is characterized to the 95th percentile above 3.6 GHz.

These notes apply to the following specifications. For more information on configuring an X-Series signal analyzer for noise figure measurements, depending on the DUT noise figure and gain, see the Noise Figure Measurement Guide, literature number N9069-90001.

Performance specifications

The following table provides noise figure specification for the UXA. For specifications for other X-Series signal analyzers, please refer to the links at the end of this section.

UXA with U7227A preamplifier

Specifications					
VSWR [1]					
	Frequency	**UXA 26.5 GHz**	**UXA 26.5 GHz + U7227A preamp full range**		**Supplemental information**
Band 0	10 to 100 MHz	1.45	3.57		
Band 0	0.1 to 2 GHz	1.45	1.54		
Band 0	2 to 3 GHz	1.45	1.73		
Band 0	3 to 3.6 GHz	1.45	1.93		
Band 1	3.5 to 4 GHz	1.54	1.93		
Band 1	4 to 8.4 GHz	1.54	—		
Band 2	8.3 to 13.6 GHz	1.57	—		
Band 3	13.5 to 17.1 GHz	1.48	—		
Band 4	17.0 to 26.5 GHz	1.54	—		
Noise figure [2, 3]					
	Frequency	**Internal preamp on**	**Internal preamp off + U7227A**	**Internal preamp on + U7227A**	**Supplemental information**
	10 MHz to 100 MHz	12.25	9.46	5.96	
	0.1 to 2.1 GHz	12.25	9.49	5.45	
	2.1 to 3.6 GHz	14.25	11.35	5.65	
	3.5 to 4.0 GHz	14.25	12.88	5.63	
	4 to 6 GHz	14.25	—	—	
	6 to 8.4 GHz	14.25	—	—	
	8.3 to 13.6 GHz	15.25	—	—	
	13.5 to 16.9 GHz	17.25	—	—	
	16.9 to 18 GHz	19.25	—	—	
	18 to 20 GHz	19.25	—	—	
	20 to 26.5 GHz	23.25	—	—	
Instrument uncertainty for noise figure [4]					
10 MHz to 26.5 GHz					
Noise source ENR	**Measurement range**	**Internal preamp on**	**Internal preamp off + U7227A**	**Internal preamp on + U7227A**	**Supplemental information**
4 to 6.5 dB	0 to 20 dB	± 0.02 dB	± 0.02 dB	± 0.02 dB	Using the internal preamp and RBW ≤ 4 MHz
12 to 17 dB	0 to 30 dB	± 0.025 dB	± 0.025 dB	± 0.025 dB	
20 to 22 dB	0 to 35 dB	± 0.03 dB	± 0.03 dB	± 0.03 dB	
Instrument uncertainty for gain [5, 6]					
	Frequency	**Internal preamp on**	**Internal preamp off + U7227A**	**Internal preamp on + U7227A**	**Supplemental information**
	10 MHz to 3.6 GHz	± 0.07	± 0.07	± 0.07	DUT gain range = –20 to +40 dB
	> 3.6 GHz	± 0.13 dB	± 0.13 dB	± 0.13 dB	
Jitter					
		Internal preamp on	**Internal preamp off + U7227A**	**Internal preamp on + U7227A**	**Supplemental information**
		± 0.15 dB	± 0.15 dB	± 0.15 dB	

UXA with U7227C preamplifier

Specifications					
VSWR [1]					
	Frequency	**UXA 26.5 GHz**	**UXA 26.5 GHz + U7227C preamp full range**		**Supplemental information**
Band 0	10 to 100 MHz	1.45	—		
Band 0	0.1 to 3.6 GHz	1.45	1.43		
Band 1	3.5 to 4 GHz	1.54	1.43		
Band 1	4 to 8.4 GHz	1.54	2.32		
Band 2	8.3 to 13.6 GHz	1.57	2.32		
Band 3	13.5 to 17.1 GHz	1.48	2.32		
Band 4	17.0 to 26.5 GHz	1.54	2.32		
Noise figure [2, 3]					
	Frequency	**Internal preamp on**	**Internal preamp off + U7227C**	**Internal preamp on + U7227C**	**Supplemental information**
	10 MHz to 100 MHz	12.25	—	—	
	0.1 to 2.1 GHz	12.25	9.88	6.36	
	2.1 to 3.6 GHz	14.25	11.60	6.52	
	3.5 to 4.0 GHz	14.25	13.06	6.51	
	4 to 6 GHz	14.25	11.64	5.56	
	6 to 8.4 GHz	14.25	10.94	4.61	
	8.3 to 13.6 GHz	15.25	10.66	4.57	
	13.5 to 16.9 GHz	17.25	13.30	4.74	
	16.9 to 18 GHz	19.25	15.77	5.06	
	18 to 20 GHz	19.25	15.37	5.77	
	20 to 26.5 GHz	23.25	20.39	6.25	
Instrument uncertainty for noise figure [4]					
10 MHz to 26.5 GHz					
Noise source ENR	**Measurement range**	**Internal preamp on**	**Internal preamp off + U7227C**	**Internal preamp on + U7227C**	**Supplemental information**
4 to 6.5 dB	0 to 20 dB	± 0.02 dB	± 0.02 dB	± 0.02 dB	Using the internal preamp and RBW ≤ 4 MHz
12 to 17 dB	0 to 30 dB	± 0.025 dB	± 0.025 dB	± 0.025 dB	
20 to 22 dB	0 to 35 dB	± 0.03 dB	± 0.03 dB	± 0.03 dB	
Instrument uncertainty for gain [5, 6]					
	Frequency	**Internal preamp on**	**Internal preamp off + U7227C**	**Internal preamp on + U7227C**	**Supplemental information**
	10 MHz to 3.6 GHz	± 0.07	± 0.07	± 0.07	DUT gain range = –20 to +40 dB
	> 3.6 GHz	± 0.13 dB	± 0.13 dB	± 0.13 dB	
Jitter					
		Internal preamp on	**Internal preamp off + U7227C**	**Internal preamp on + U7227C**	**Supplemental information**
		± 0.15 dB	± 0.15 dB	± 0.15 dB	

1. Analyzer VSWR is characterized to the 95th percentile but not measured and warranted. The VSWR measurement is made on the PNA-X which is traceable. The reverse isolation of the USAB preamp is high enough that the system VSWR is insignificantly affected by the analyzer VSWR. So the system VSWR is the warranted VSWR of the USB preamp.
2. Analyzer noise figure is computed from the specified DANL using NF = D - (K - L + B) where D is the DANL (displayed average noise level), K is kTB (-173.98 dBm in a 1 Hz bandwidth at 290 K), L is 2.51 dB (the effect of log averaging used in DANL verifications), N is 0.24 dB (the ratio of the noise bandwidth of the RBW filter with which the DANL is specified to an ideal noise bandwidth), B is ten times the base-10 logarithm of the RBW (in hertz) in which the DANL is specified. B is 0 dB for the 1 Hz RBW. The actual NF will vary from the nominal due to frequency response errors. Frequency response errors help as often as they harm, so NF derived from the DANL is a very good approximation to the true NF. Any other uncertainties created by deriving the noise figure are small second-order uncertainties the GUM does not require.
3. Noise figure for the combination of USB preamp and analyzer is NFsys = 10*Log(Fpreamp + (Fanalyzer - 1)/Gpreamp). The noise figure and gain of the preamp are specified and warranted. The noise figure of the analyzer is derived and discussed in [2]. The uncertainty due to the noise figure of the analyzer is smaller than [2].
4. “Instrument Uncertainty” is defined for noise figure analysis as uncertainty due to relative amplitude uncertainties encountered in the analyzer when making the measurements required for a noise figure computation. The relative amplitude uncertainty depends on, but is not identical to, the relative display scale fidelity, also known as incremental log fidelity. The uncertainty of the analyzer is multiplied within the computation by an amount that depends on the Y factor to give the total uncertainty of the noise figure or gain measurement. See Keysight App Note 57-2, literature number 5952-3706E for details on the use of this specification. Jitter (amplitude variations) will also affect the accuracy of results. The standard deviation of the measured result decreases by a factor of the square root of the Resolution Bandwidth used and by the square root of the number of averages. This application uses the 4 MHz Resolution Bandwidth as default because this is the widest bandwidth with uncompromised accuracy.
5. “Instrument Uncertainty” is defined for gain measurements as uncertainty due to relative amplitude uncertainties encountered in the analyzer when making the measurements required for the gain computation. See Keysight App Note 57-2, literature number 5952-3706E for details on the use of this specification. Jitter (amplitude variations) will also affect the accuracy of results. The standard deviation of the measured result decreases by a factor of the square root of the Resolution Bandwidth used and by the square root of the number of averages. This application uses the 4 MHz Resolution Bandwidth as default since this is the widest bandwidth with uncompromised accuracy.
6. Instrument uncertainty for gain is characterized to the 95th percentile above 3.6 GHz.

Note: Data subject to change

For a complete list of specifications, refer to the appropriate specifications guide:

UXA: www.keysight.com/find/uxa_specifications

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

PXIe:

VSA up to 6 GHz: www.keysight.com/find/m9391a

VSA up to 50 GHz: www.keysight.com/find/m9393a

VXT up to 6 GHz: www.keysight.com/find/m9411a

VXT up to 12 GHz: www.keysight.com/find/m9415a

VXT up to 12 GHz: www.keysight.com/find/m9416a

NFA N8973B with U7227A preamplifier

Specifications					
VSWR [1]					
	Frequency	**N8973B full range**	**N8973B + U7227A preamp full range**		**Supplemental information**
Band 0	10 to 100 MHz	2.2	3.57		
	0.1 to 2 GHz	2.2	1.54		
	2 to 3 GHz	2.2	1.73		
	3 to 3.6 GHz	2.2	1.93		
Noise figure [2, 3]					
	Frequency	**Internal preamp on**	**Internal preamp off + U7227A**	**Internal preamp on + U7227A**	**Supplemental information**
	10 MHz to 100 MHz	15.25	14.79	6.40	
	0.1 to 2.1 GHz	15.25	13.81	5.80	
	2.1 to 3.6 GHz	16.25	13.81	5.81	
Instrument uncertainty for noise figure [4]					
10 MHz to 3.6 GHz					
Noise source ENR	**Measurement range**	**Internal preamp on**	**Internal preamp off + U7227A**	**Internal preamp on + U7227A**	**Supplemental information**
4 to 6.5 dB	0 to 20 dB	± 0.02 dB	± 0.02 dB	± 0.02 dB	Using the internal preamp and RBW ≤ 4 MHz
12 to 17 dB	0 to 30 dB	± 0.025 dB	± 0.025 dB	± 0.025 dB	
20 to 22 dB	0 to 35 dB	± 0.03 dB	± 0.03 dB	± 0.03 dB	
Instrument uncertainty for gain [5, 6]					
	Frequency	**Internal preamp on**	**Internal preamp off + U7227A**	**Internal preamp on + U7227A**	**Supplemental information**
	10 MHz to 3.6 GHz	± 0.15 dB	± 0.15 dB	± 0.15 dB	DUT gain range = –20 to +40 dB

NFA N8974B with U7227C preamplifier

Specifications					
VSWR [1]					
	Frequency	**N8974B full range**	**N8974B + U7227C preamp full range**		**Supplemental information**
Band 0	10 to 100 MHz	2.2	—		
	100 MHz to 4 GHz	2.2	1.29		
	4 to 7 GHz	2.2	1.78		
Noise figure [2, 3]					
	Frequency	**Internal preamp on**	**Internal preamp off + U7227C**	**Internal preamp on + U7227C**	**Supplemental information**
	10 to 100 MHz	15.25	—	—	
	100 MHz to 2.1 GHz	15.25	14.74	6.79	
	2.1 to 3.6 GHz	16.25	15.16	6.88	
	3.5 to 4.0 GHz	16.25	14.82	6.81	
	4 to 6 GHz	16.25	14.61	5.97	
	6 to 7 GHz	16.25	14.04	5.08	
Instrument uncertainty for noise figure [4]					
10 MHz to 7 GHz					
Noise source ENR	**Measurement range**	**Internal preamp on**	**Internal preamp off + U7227C**	**Internal preamp on + U7227C**	**Supplemental information**
4 to 6.5 dB	0 to 20 dB	± 0.02 dB	± 0.02 dB	± 0.02 dB	Using the internal preamp and RBW ≤ 4 MHz
12 to 17 dB	0 to 30 dB	± 0.025 dB	± 0.025 dB	± 0.025 dB	
20 to 22 dB	0 to 35 dB	± 0.03 dB	± 0.03 dB	± 0.03 dB	
Instrument uncertainty for gain [5, 6]					
	Frequency	**Internal preamp on**	**Internal preamp off + U7227C**	**Internal preamp on + U7227C**	**Supplemental information**
	10 MHz to 3.6 GHz	+/- 0.15 dB	+/- 0.15 dB	+/- 0.15 dB	DUT gain range = –20 to +40 dB
	> 3.6 GHz	+/- 0.26 dB	+/- 0.26 dB	+/- 0.26 dB	

NFA N8975B with U7227C preamplifier

Specifications					
VSWR [1]					
	Frequency	**N8975B full range**	**N8975B + U7227C preamp full range**		**Supplemental information**
Band 0	10 to 100 MHz	2.2	—		
	100 MHz to 4 GHz	2.2	1.29		
	4 to 26.5 GHz	2.2	1.78		
Noise figure [2, 3]					
	Frequency	**Internal preamp on**	**Internal preamp off + U7227C**	**Internal preamp on + U7227C**	**Supplemental information**
	10 to 100 MHz	15.25	—	—	
	100 MHz to 2.1 GHz	15.25	14.74	6.79	
	2.1 to 3.6 GHz	16.25	15.16	6.88	
	3.5 to 4.0 GHz	16.25	14.82	6.81	
	4 to 6 GHz	16.25	14.61	5.97	
	6 to 7 GHz	16.25	14.04	5.08	
	7 to 13.6 GHz	16.25	17.53	5.02	
	13.5 to 17 GHz	19.25	22.67	5.34	
	17 to 18 GHz	21.25	21.80	5.67	
	18 to 20 GHz	21.25	21.57	6.30	
	20 to 26.5 GHz	26.25	24.99	7.98	
Instrument uncertainty for noise figure [4]					
10 MHz to 26.5 GHz					
Noise source ENR	**Measurement range**	**Internal preamp on**	**Internal preamp off + U7227C**	**Internal preamp on + U7227C**	**Supplemental information**
4 to 6.5 dB	0 to 20 dB	± 0.02 dB	± 0.02 dB	± 0.02 dB	Using the internal preamp and RBW ≤ 4 MHz
12 to 17 dB	0 to 30 dB	± 0.025 dB	± 0.025 dB	± 0.025 dB	
20 to 22 dB	0 to 35 dB	± 0.03 dB	± 0.03 dB	± 0.03 dB	
Instrument uncertainty for gain [5, 6]					
	Frequency	**Internal preamp on**	**Internal preamp off + U7227C**	**Internal preamp on + U7227C**	**Supplemental information**
	10 MHz to 3.6 GHz	+/- 0.15 dB	+/- 0.15 dB	+/- 0.15 dB	DUT gain range = –20 to +40 dB
	> 3.6 GHz	+/- 0.26 dB	+/- 0.26 dB	+/- 0.26 dB	

NFA N8976B with U7227F preamplifier

Specifications

VSWR [1]					
	Frequency	**N8976B full range**	**N8976B + U7227F preamp full range**		**Supplemental information**
Band 0	10 MHz to 2 GHz	2.2	—		
	2 to 4 GHz	2.2	1.29		
	4 to 40 GHz	2.2	1.78		
Noise figure [2, 3]					
	Frequency	**Internal preamp on**	**Internal preamp off + U7227F**	**Internal preamp on + U7227F**	**Supplemental information**
	10 MHz to 1.2 GHz	12.25	—	—	
	1.2 to 2 GHz	13.25	—	—	
	2 to 2.1 GHz	13.25	12.65	10.17	
	2.1 to 3.6 GHz	14.25	13.49	10.20	
	3.5 to 4.0 GHz	16.25	17.65	10.31	
	4 to 4.2 GHz	16.25	16.76	8.42	
	4.2 to 8.4 GHz	16.25	13.56	8.21	
	8.3 to 13.6 GHz	16.25	11.35	8.15	
	13.5 to 20 GHz	16.25	11.76	8.11	
	20 to 26.5 GHz	18.25	13.40	8.16	
	26.4 to 34 GHz	20.25	15.42	8.19	
	33.9 to 40 GHz	23.25	19.84	8.37	
Instrument uncertainty for noise figure [4]					
10 MHz to 40 GHz					
Noise source ENR	**Measurement range**	**Internal preamp on**	**Internal preamp off + U7227F**	**Internal preamp on + U7227F**	**Supplemental information**
4 to 6.5 dB	0 to 20 dB	± 0.02 dB	± 0.02 dB	± 0.02 dB	Using the internal preamp and RBW ≤ 4 MHz
12 to 17 dB	0 to 30 dB	± 0.025 dB	± 0.025 dB	± 0.025 dB	
20 to 22 dB	0 to 35 dB	± 0.03 dB	± 0.03 dB	± 0.03 dB	
Instrument uncertainty for gain [5, 6]					
	Frequency	**Internal preamp on**	**Internal preamp off + U7227F**	**Internal preamp on + U7227F**	**Supplemental information**
	10 MHz to 3.6 GHz	+/- 0.15 dB	+/- 0.15 dB	+/- 0.15 dB	DUT gain range = –20 to +40 dB
	> 3.6 GHz	+/- 0.26 dB	+/- 0.26 dB	+/- 0.26 dB	

1. N8973/4/5/6B VSWR spec is the nominal spec when the input attenuation is 0 dB. The reverse isolation of the USB preamp is high enough that the system VSWR is insignificantly affected by the analyzer VSWR. So the system VSWR is the warranted VSWR of the USB preamp.
2. Analyzer noise figure is computed from the specified DANL using NF = D - (K - L + B) where D is the DANL (displayed average noise level), K is kTB (-173.98 dBm in a 1 Hz bandwidth at 290 K) L is 2.51 dB (the effect of log averaging used in DANL verifications). N is .24 dB (the ratio of the noise bandwidth of the RBW filter with which the DANL is specified to an ideal noise bandwidth) B is ten times the base-10 logarithm of the RBW (in hertz) in which the DANL is specified. B is 0 dB for the 1 Hz RBW. The actual NF will vary from the nominal due to frequency response errors. Frequency response errors help as often as they harm, so NF derived from the DANL is a very good approximation to the true NF. Any other uncertainties created by deriving the noise figure are small second-order uncertainties the GUM does not require.
3. Noise figure for the combination of USB preamp and analyzer is NFsys = 10*Log(Fpreamp + (Fanalyzer - 1)/Gpreamp). The noise figure and gain of the preamp are specified and warranted. The noise figure of the analyzer is derived and discussed in [2].
4. "Instrument Uncertainty" is defined for noise figure analysis as uncertainty due to relative amplitude uncertainties encountered in the analyzer when making the measurements required for a noise figure computation. The relative amplitude uncertainty depends on, but is not identical to, the relative display scale fidelity, also known as incremental log fidelity. The uncertainty of the analyzer is multiplied within the computation by an amount that depends on the Y factor to give the total uncertainty of the noise figure or gain measurement. See Keysight App Note Noise Figure Measurement Accuracy: The Y-Factor Method, literature number 5952-3706E for details on the use of this specification. Jitter (amplitude variations) will also affect the accuracy of results. The standard deviation of the measured result decreases by a factor of the square root of the Resolution Bandwidth used and by the square root of the number of averages. This application uses the 4 MHz Resolution Bandwidth as default because this is the widest bandwidth with uncompromised accuracy. The instrument uncertainties shown are under best-case sweep time conditions, which is a sweep time near to the period of the power line, such as 20 ms for 50 Hz power sources. The behavior can be greatly degraded (uncertainty increased nominally by 0.12 dB) by setting the sweep time per point far from an integer multiple of the period of the line frequency.
5. "Instrument Uncertainty" is defined for gain measurements as uncertainty due to relative amplitude uncertainties encountered in the analyzer when making the measurements required for the gain computation. See Keysight App Note 57-2, literature number 5952-3706E for details on the use of this specification. Jitter (amplitude variations) will also affect the accuracy of results. The standard deviation of the measured result decreases by a factor of the square root of the Resolution Bandwidth used and by the square root of the number of averages. This application uses the 4 MHz Resolution Bandwidth as default since this is the widest bandwidth with uncompromised accuracy.
5. "Instrument Uncertainty" is defined for gain measurements as uncertainty due to relative amplitude uncertainties encountered in the analyzer when making the measurements required for the gain computation. See Keysight App Note Noise Figure Measurement Accuracy: The Y-Factor Method, literature number 5952-3706E for details on the use of this specification. Jitter (amplitude variations) will also affect the accuracy of results. The standard deviation of the measured result decreases by a factor of the square root of the Resolution Bandwidth used and by the square root of the number of averages. This application uses the 4 MHz Resolution Bandwidth as default since this is the widest bandwidth with uncompromised accuracy.
6. Instrument uncertainty for gain is characterized to the 95th percentile above 3.6 GHz.

Note: Data subject to change

For a complete list of specifications, refer to the appropriate specifications guide:

NFA: http://www.keysight.com/find/nfa_specifications

Computing measurement uncertainty

Keysight provides three versions of noise figure uncertainty calculation, including

- Built-in noise figure uncertainty calculator (NFUC) enables you to calculate measurement uncertainty directly using the current measurement results.
- Spreadsheet version gives you the most freedom to enter DUT information and instrument specifications to get an accurate noise figure uncertainty. The spreadsheet version of the NFUC can be found at: www.keysight.com/find/nfu

Ordering Information

Flexible licensing and configuration

Flexible licensing options enable you to balance your project's requirements. Your application software may require consistent software operation over a full program lifecycle or may require frequent updates to keep pace with fast-moving, leading-edge applications. Keysight licensing has flexible license terms and types to address your application needs. KeysightCare provides selectable software support subscription as well.

License term	Description
Perpetual	Software license can be used in perpetuity
Subscription (time-based)	Software license is time limited to a defined period, such as 12 months, 24 months or 36 months. KeysightCare Software Support is included through the license term.
Software support subscription	Allows the perpetual license holder access to Keysight technical support and all software upgrades

License type	Description
Node locked	Allows you to use the licenses on one specified instrument/computer
Transportable	Allows you to use the license on one instrument/computer at a time. You can transfer the license to another instrument/computer using the online tool, Keysight Software Manager (internet connection required)
USB portable	Allows you to use a USB portable license on one instrument/computer at a time. You can transfer the license to another instrument using a certified USB dongle (available for additional purchase, Keysight part number E8900-D10)
Floating	Networked instruments/computers can access a license from a server, one at a time. You need purchase multiple licenses for concurrent usage. Three types of floating license are available: Single Site: 1-mile radius from the server; Single Region [1]: Americas; Europe; Asia; Worldwide: export restriction identified in End User License Agreement (EULA)

1. Americas (North, Central, and South America, Canada); Europe (European Continent, Middle Eastern Europe, Africa, India); Asia (North and South Asia Pacific Countries, China, Taiwan, Japan)

Noise figure measurement application (N9069EM0E/E9069EM0E/W9069EM0E)

	Software license type	Software license	KeysightCare subscription
Perpetual	Node-locked	SW1000-LIC-01	SW1000-SUP-01
	Transportable		
Time-based	Node-locked	SW1000-SUB-01	Included
	Transportable		

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 configuration

Signal analyzer

For optimizing measurements on signals with the noise figure measurement application, Keysight recommends a minimum level of X-Series multi-touch instrument hardware functionality at each instrument performance point. Supported instruments include:

Benchtop:

- UXA N9040B / N9041B / N9042B (N9069EM0E)
- PXA N9030B / N9032B [1] (N9069EM0E)
- MXA N9020B / N9021B (N9069EM0E/E9069EM0E)
- EXA N9010B (N9069EM0E/E9069EM0E)
- CXA N9000B (N9069EM0E/E9069EM0E/W9069EM0E)
- NFA N8973B/N8974B/N8975B/N8976B

PXIe:

- PXIe VSA M9391A (N9060EM0E)
- PXIe VSA M9393A (N9069EM0E)
- PXIe VXT M9421A (N9069EM0E/E9069EM0E)
- PXIe VXT M9410A/M9411A (N9069EM0E/E9069EM0E)
- PXIe VXT M9415A (N9069EM0E/E9069EM0E)
- PXIe VXT M9416A (N9069EM0E/E9069EM0E)

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

X-Series signal analyzer

Capability	Instrument option	Benefit
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
External mixer	EXM	**Recommended:** For UXA N9042B working with V3050A

1. N9032B 55 GHz model supports noise figure measurement application with XA2025 (XA39) release or above.

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

PXIe VXT vector transceiver

Description	Model option	Additional information
Frequency range 3.8 or 6 GHz	M9421A-504, or 506	One required for M9421A
Frequency range 6 GHz	M9410A/M9411A-001	One required for M9410A/M9411A
Frequency range 6, 8, or 12 GHz	M9415A-F06, F08 or F12	One required for M9415A/M9416A
Analysis bandwidth 40, 80 or 160 MHz	M9421A-B40, B80 or B1X	One required for M9421A
Analysis bandwidth 300, 600 MHz or 1.2 GHz	M9410A/M9411A-B3X, B6X or B12	One required for M9410A/M9421A
Analysis bandwidth 400, 800 MHz or 1.2 GHz	M9415A-B4X, B8X or B12	One required for M9415A/M9416A
Memory 256 or 512 MSa	M9421A/M9410A/M9411A/M9415A/ M9416A-M02 or M05	One required
Calibration for spectrum analyzer	SAA	One required

Noise source

Noise sources work with the full range of Keysight noise figure measurement solutions. They are categorized by frequency coverage as well as excess noise ratio (ENR).

346 and 347 Series noise sources work in conjunction with Keysight analyzers to make noise-figure measurements from 10 MHz to 50 GHz, providing low SWR and individually calibrated ENR values at specific frequencies.

With the smart noise sources, like SNA Series and USB Smart Series, ENR data is stored in an EPROM and is automatically downloaded to the instrument, eliminating the need to manually enter the values into the calibration table at each cardinal frequency point. In addition, a thermistor is built into the sensor to continually update the analyzer with the correct temperature, delivering automatic temperature compensation/correction within the measurement's source.

When frequency range is above 50 GHz, refer to Noise Source recommended for V/E/W/D/H band noise figure measurements.

Noise source	Frequency range	ENR range	ENR nominal	Work with
346 Series				
346A	10 MHz to 18 GHz	5 to 7 dB	6 dB	• X-Series signal analyzers • PXIe VSA vector signal analyzers • PXIe VXT vector transceivers
346B	10 MHz to 18 GHz	14 to 16 dB	15 dB	
346C	10 MHz to 26 GHz	12 to 17 dB	15 dB	
346CK01	1 GHz to 50 GHz	• 1 GHz: 20 dB • 50 GHz: 7 dB	-	
347 Series				
Q347B	33 GHz to 50 GHz	• 33 to 42 GHz: 14 to 17 dB • 42 to 50 GHz: 9 to 16 dB	-	• X-Series signal analyzers • PXIe VSA vector signal analyzers • PXIe VXT vector transceivers
R347B	26.5 GHz to 40 GHz	14 to 17 dB	-	
SNS Series				
N4000A	10 MHz to 18 GHz	4.6 to 6.5 dB	6 dB	• X-Series signal analyzers • PXIe VSA vector signal analyzers
N4001A	10 MHz to 18 GHz	14 to 16 dB	15 dB	
N4002A	10 MHz to 26.5 GHz	12 to 17 dB	15 dB	
USB Smart Noise Source				
U1831C	10 MHz to 26.5 GHz	12 to 17 dB	15 dB	• X-Series signal analyzers • PXIe VSA vector signal analyzers • PXIe VXT vector transceivers
U1832A	10 MHz to 18 GHz	4.5 to 6.5 dB	5 dB	X-Series signal analyzers (excluding CXA)
U1832B	10 MHz to 26.5 GHz	4 to 7 dB	5 dB	
U1832C	500 MHz to 50 GHz	3.5 to 8.5 dB	5 dB	
U1833A	10 MHz to 18 GHz	14 to 16 dB	15 dB	X-Series signal analyzers (excluding CXA)
U1833B	10 MHz to 26.5 GHz	12 to 17 dB	15 dB	
U1833C	500 MHz to 50 GHz	10 to 21 dB	15 dB	
U1833D	500 MHz to 60 GHz	6 to 21 dB	10 dB	

Note: If the DUT noise figure is beyond 30 dB, then the Keysight PNA-X Option 029 for noise figure measurements on a network analyzer may be more suitable than the Y-factor method.

USB preamplifiers

The U7227A/C/F and U7228A/C/F USB preamplifiers are designed to increase signal analyzer sensitivity for measuring low-level signals by reducing instrument noise figure. In most cases, reduced instrument noise figure also reduces noise figure measurement uncertainty of Y-factor noise figure measurements.

Specification [1]	U7227A/U7228A	U7227A/U7228C	U7227A/U7228F
Frequency	10 MHz to 4 GHz	100 MHz to 26.5 GHz	2 GHz to 50 GHz
Gain (dB) [2]	• 10 to 100 MHz: > 16 • 100 MHz to 4 GHz: > 0.5F + 17	100 MHz to 26.5 GHz: > 16.1 + 0.26F	2 to 50 GHz: > 16.5 + 0.23F
Input return loss (Input SWR)	• 10 to 100 MHz: > 5 dB (3.57) • 100 MHz to 2 GHz: > 13.5 dB (1.54) • 2 to 3 GHz: > 11.5 dB (1.73) • 3 to 4 GHz: > 10 dB (1.93)	• 100 MHz to 4 GHz: > 15 dB (1.43) • 4 to 26.5 GHz: > 8 dB (2.32)	• 2 GHz to 40 GHz: > 8 dB (2.32) • 40 to 44 GHz: > 6 dB (3.00) • 44 to 50 GHz: > 5 dB (3.57)
Output return loss (Output SWR)	10 MHz to 4 GHz: > 18 dB (1.29)	• 100 MHz to 4 GHz: > 18 dB (1.29) • 4 to 26.5 GHz: > 11 dB (1.78)	**U7227F** • 2 GHz to 4 GHz: > 18 dB (1.29) • 4 to 40 GHz: > 11 dB (1.78) • 40 to 50 GHz: > 8 dB (2.32) **U7228F** • 2 to 4 GHz: > 18 dB (1.29) • 4 to 26.5 GHz: > 11 dB (1.78) • 26.5 to 40 GHz: > 8 dB (2.32) • 40 to 50 GHz: > 6 dB (3.00)
Noise figure	• 10 to 100 MHz: < 5.5 dB • 10 MHz to 4 GHz: < 5 dB	• 100 MHz to 4 GHz: < 6 dB • 4 to 6 GHz: < 5 dB • 6 to 18 GHz: < 4 dB • 18 to 26.5 GHz: < 5 dB	• 2 to 4 GHz: < 10 dB • 4 to 40 GHz: < 8 dB • 40 to 44 GHz: < 9 dB • 44 to 50 GHz: < 10 dB
Plug and play USB connection	Yes	Yes	Yes
Optimized gain slope for better spectrum analysis	Yes	Yes	Yes
Automatic gain compensation	Yes	Yes	Yes
Automatic temperature compensation	Yes	Yes	Yes

1 Specifications are tested and measured with an operating temperature of 23 °C.
2 "F" signifies frequency in GHz.

Selection guide for noise figure measurement above 50 GHz

Frequency range	Recommended solution	Noise source	Downconverter [1]	External LO [2]	X-series signal analyzer + Noise figure application	Notes
• V-band (50-75 GHz) • E-band (60-90 GHz)	V3050A + UXA N9042B	• U1833D up to 60 GHz • Noisecom NC5000A Series	V3050A	NA	N9042B + N9069EM0E	• External LNA could be required > 80 GHz • V3050A preselected path up to 87.5GHz
• V-band (50-75 GHz) • E-band (60-90 GHz)	N9029BV + MXA N9020B + External LO	Noisecom NC5000A Series	• N9029BV-W15 • N9029AV12 • N9029BV-W12	• N5183B MXG • E8257D PSG	N9020B + N9069EM0E	Other X-series signal analyzers would also work [1]
W-band (75-110 GHz)	N9029BV + MXA N9020B + External LO	• Noisecom NC5000A Series • N9029AV10-NSM[3]	• N9029BV-W10	• N5183B MXG • E8257D PSG	N9020B + N9069EM0E	Other X-series signal analyzers would also work [1]
D-band (110-170 GHz)	N9029BV + MXA N9020B + External LO	N9029AV06-NSM[3]	• N9029BV-W06	• N5183B MXG • E8257D PSG	N9020B + N9069EM0E	• Other X-series signal analyzers would also work [1] • Isolator is recommended
H-band (220-330 GHz)	N9029BV + MXA N9020B + External LO	N9029AV03-NSM[3]	• N9029BV-W03	• N5183B MXG • E8257D PSG	N9020B + N9069EM0E	• Other X-series signal analyzers would also work [1] • Isolator is recommended

1 UXA/PXA/MXE/EXA can work with N9029BV modules and require Option EXM. CXA does not work with N9029BV modules.
2 Other analog PSG and analog microwave MXG/EXG can also work as the external LO.
3. Order the N9029AV03/06/10-NSM through N9029AV99 Accessories for Millimeter Wave Frequency Extension Modules

Related Literature

Fundamentals of RF and Microwave Noise Figure Measurements
– Application Note, literature number 5952-8255EN

Noise Figure Measurement Accuracy – the Y-factor method
– Application Note, literature number 5952-3706EN

10 Hints for Making Successful Noise Figure Measurements
– Application Note, literature number 5980-0288E

Minimize Noise Figure Uncertainties
– Technical Overview, literature number 5989-8056EN

How to Make D-band Noise Figure Measurement with Signal Analyzer
– Application Note, literature number 3122-1579.EN

Keysight N4000A, N4001A, N4002A SNS Series Noise Sources 10 MHz to 26.5 GHz
– Technical Overview, literature number 5988-0081EN

Keysight USB Preamplifiers U7227A/C/F
– Technical Overview, literature number 5991-4246EN

Web

Noise figure X-Series measurement app, multi-touch UI product webpage:
www.keysight.com/find/N9069EM0E

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

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