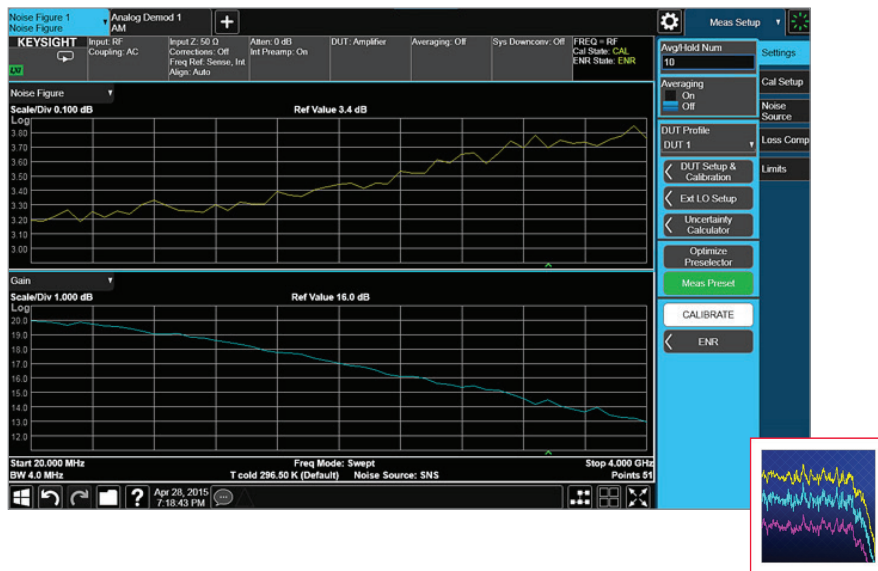# Keysight Technologies
Noise Figure
X-Series Measurement App, Multi-Touch
N9069C

Technical Overview

– Characterize noise figure and gain of connectorized devices and system blocks with graph, meter, and table layouts and built-in uncertainty calculator

– Provide fully-specified measurements with optional internal preamp; improved specifications with external USB preamp

– Speed up multi-DUT measurements with multi-DUT calibration and measurement profiles

– Extend noise figure measurements to 110 GHz (Option 526 or greater required) with Keysight's K-Series block downconverters

– Use multi-touch front panel user interface or SCPI remote interface

– Extend test assets with transportable licenses between all X-Series signal analyzers with multi-touch UI

KEYSIGHT TECHNOLOGIES

Unlocking Measurement Insights

Noise Figure Measurement Application

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. N9069C 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.

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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.

Learn more at:
www.keysight.com/find/nfa

Top Features

Noise figure and gain measurements for amplifier and converters

The N9069C 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.
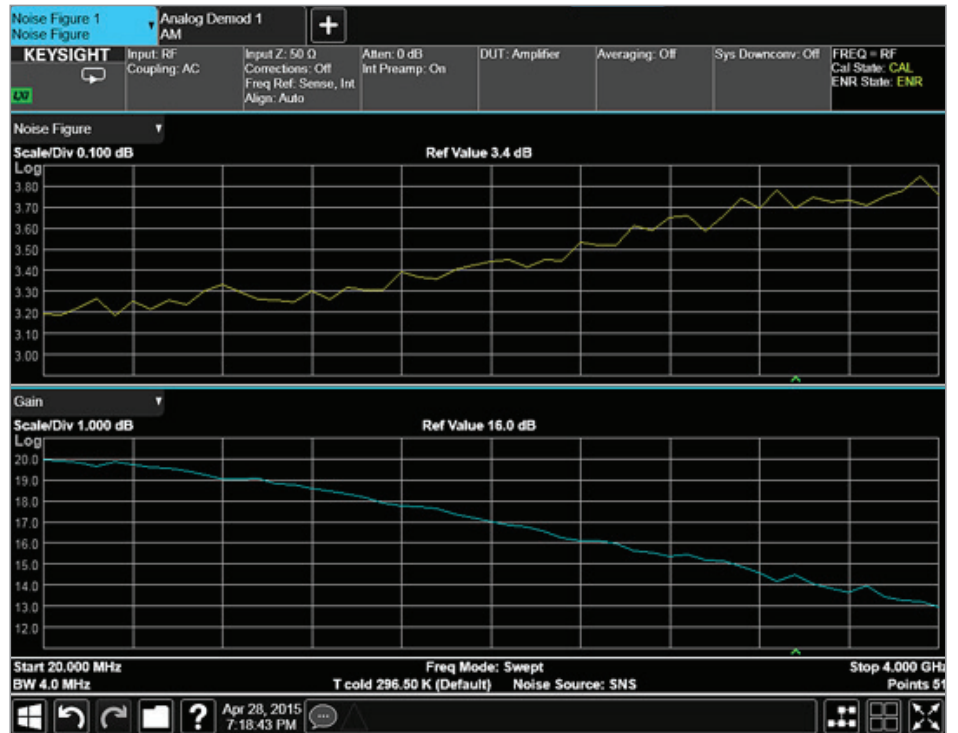
Multi-DUT calibration and measurement profiles

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

Simultaneous display of multi-results in table format and 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.

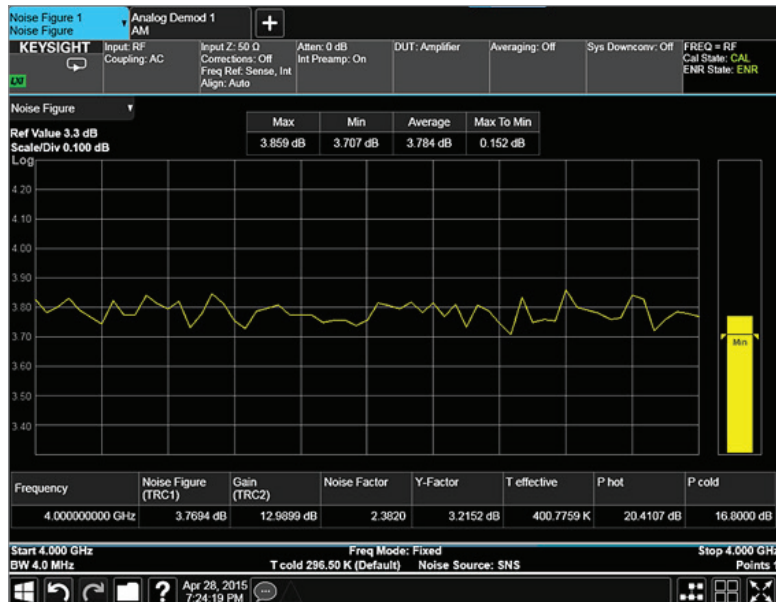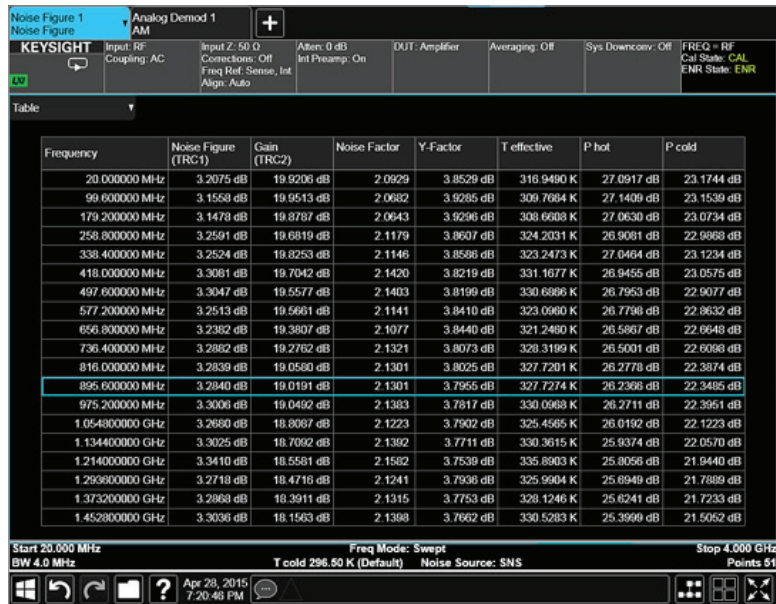| Frequency	Noise Figure (TRC1)	Gain (TRC2)	Noise Factor	Y-Factor	T effective	P hot	P cold
20.000000 MHz	3.2075 dB	19.9206 dB	2.0929	3.8529 dB	316.9490 K	27.0917 dB	23.1744 dB
99.600000 MHz	3.1558 dB	19.9513 dB	2.0682	3.9285 dB	309.7664 K	27.1409 dB	23.1539 dB
179.200000 MHz	3.1478 dB	19.8787 dB	2.0643	3.9296 dB	308.6608 K	27.0630 dB	23.0734 dB
258.800000 MHz	3.2591 dB	19.6819 dB	2.1179	3.8607 dB	324.2031 K	26.9081 dB	22.9868 dB
338.400000 MHz	3.2524 dB	19.8253 dB	2.1146	3.8586 dB	323.2473 K	27.0464 dB	23.1234 dB
418.000000 MHz	3.3081 dB	19.7042 dB	2.1420	3.8219 dB	331.1677 K	26.9455 dB	23.0575 dB
497.600000 MHz	3.3047 dB	19.5577 dB	2.1403	3.8199 dB	330.6896 K	26.7953 dB	22.9077 dB
577.200000 MHz	3.2513 dB	19.5661 dB	2.1141	3.8410 dB	323.0960 K	26.7798 dB	22.8632 dB
656.800000 MHz	3.2382 dB	19.3807 dB	2.1077	3.8440 dB	321.2460 K	26.5867 dB	22.6648 dB
736.400000 MHz	3.2882 dB	19.2762 dB	2.1321	3.8073 dB	328.3199 K	26.5001 dB	22.6098 dB
816.000000 MHz	3.2839 dB	19.0580 dB	2.1301	3.8025 dB	327.7201 K	26.2778 dB	22.3874 dB
895.600000 MHz	3.2840 dB	19.0191 dB	2.1301	3.7955 dB	327.7274 K	26.2366 dB	22.3485 dB
975.200000 MHz	3.3006 dB	19.0492 dB	2.1383	3.7817 dB	330.0968 K	26.2711 dB	22.3951 dB
1.054800000 GHz	3.2680 dB	18.8087 dB	2.1223	3.7902 dB	325.4585 K	26.0192 dB	22.1223 dB
1.134400000 GHz	3.3025 dB	18.7092 dB	2.1392	3.7711 dB	330.3615 K	25.9374 dB	22.0570 dB
1.214000000 GHz	3.3410 dB	18.5581 dB	2.1582	3.7539 dB	335.8903 K	25.8056 dB	21.9440 dB
1.293600000 GHz	3.2718 dB	18.4716 dB	2.1241	3.7936 dB	325.9904 K	25.6949 dB	21.7889 dB
1.373200000 GHz	3.2868 dB	18.3911 dB	2.1315	3.7753 dB	328.1246 K	25.6241 dB	21.7233 dB
1.452800000 GHz	3.3036 dB	18.1563 dB	2.1398	3.7662 dB	330.5283 K	25.3999 dB	21.5052 dB

Start 20.000 MHz — BW 4.0 MHz — Freq Mode: Swept — T cold 296.50 K (Default) — Noise Source: SNS — Stop 4.000 GHz — Points 51

Meter view — Ref Value 3.3 dB — Scale/Div 0.100 dB — Log

	Max	Min	Average	Max To Min
	3.859 dB	3.707 dB	3.784 dB	0.152 dB

Frequency	Noise Figure (TRC1)	Gain (TRC2)	Noise Factor	Y-Factor	T effective	P hot	P cold
4.000000000 GHz	3.7694 dB	12.9899 dB	2.3820	3.2152 dB	400.7759 K	20.4107 dB	16.8000 dB

Start 4.000 GHz — BW 4.0 MHz — Freq Mode: Fixed — T cold 296.50 K (Default) — Noise Source: SNS — Stop 4.000 GHz — Points 1

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.

Uncertainty Calculator

Automate settings from DUT setup and measurement results — On / Off
Update at current CF 2.010000000 GHz
Update at selected frequency 500.0000000 MHz

DUT: Amplifier — NS: Auto — Freq: 500.00 MHz — Ext Preamp: Auto — Instrument: Auto — Freq: 500.00 MHz

		Spec Style	Distribution
DUT NF (dB)	3.276 dB	Fixed*	
DUT Gain (dB)	19.200 dB	Fixed*	
DUT In Match**	1.200	Fixed	Fixed
DUT Out Match**	1.200	Fixed	Fixed
NS ENR Uncert (dB)	0.106 dB	95th %ile*	Gaussian*
NS Match**	0.006	Maximum	Rayleigh
Inst NF (dB)	9.800 dB	Fixed*	
Inst NF Uncert (dB)	0.020 dB	Fixed*	Gaussian*
Inst Gain Uncert (dB)	0.070 dB	Fixed*	Gaussian*
Inst Match**	1.560	95th %ile	Rayleigh
Inst NFE Impr (dB)	10.000 dB	95th %ile*	Gaussian*
Ext PA NF (dB)	5.009 dB	Fixed*	
Ext PA Gain (dB)	23.303 dB	Fixed*	
Ext PA Match**	-22.055	Fixed	Fixed
Ext PA NFE Impr (dB)	9.000 dB	95th %ile*	Gaussian*

* Fixed value, not editable
** May be entered as Return Loss (-xx.x dB), VSWR or Refl Coefficient

Sweep

Parameter	Lower	Upper	Points	User Cal	Int Cal	Uncal
DUT NF	1.638	4.913	15	On	On	On

Noise Figure Uncertainty, 2σ

User Cal	±0.107 dB
Internal Cal	±0.107 dB
Uncalibrated	±0.145 dB

Sweep Uncertainty — Log
0.168
0.161
0.153
0.146
0.138
0.130
0.123
0.115
0.108
1.63779395609046 — 4.91338186827137

Java online uncertainty calculator: <http://www.keysight.com/find/nfu>

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

UXA with U7227A preamplifier

Description			Specifications		Supplemental information
VSWR[1]	Frequency	UXA full range	UXA 26.5 GHz + U7227A preamp full range		
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]		Internal preamp on	Internal preamp off + U7227A	Internal preamp on + U7227A	
	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				
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]					
	10 MHz to 3.6 GHz	± 0.07 dB	± 0.07 dB	± 0.07 dB	DUT gain range = –20 to +40 dB
	> 3.6 GHz	± 0.13 dB	± 0.13 dB	± 0.13 dB	
Jitter		± 0.15 dB	± 0.15 dB	± 0.15 dB	

Performance specifications

UXA with U7227C preamplifier

Description		Specifications			Supplemental information
VSWR[1]	Frequency	UXA full range	UXA 26.5 GHz + U7227C preamp full range		
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]		Internal preamp on	Internal preamp off + U7227A	Internal preamp on + U7227A	
	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				
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]					
	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		± 0.15 dB	± 0.15 dB	± 0.15 dB	

Performance specifications

PXA with U7227A preamplifier

	Frequency	PXA full range	PXA + U7227A full range
VSWR[1]			
	Frequency		
	10 to 100 MHz	1.45	3.57
	0.1 to 2 GHz	1.45	1.54
	2 to 3 GHz	1.45	1.73
	3 to 3.6 GHz	1.45	1.93
	3.5 to 4 GHz	1.54	1.93
	4 to 8.4 GHz	1.54	–
	8.3 to 13.6 GHz	1.57	–
	13.5 to 17.1 GHz	1.48	–
	17.0 to 26.5 GHz	1.54	–

		Internal preamp on	Internal preamp off + U7227A	Internal preamp on + U7227A	Supplemental information
Noise figure[2,3]					
	10 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	5.56	
	3.5 to 4 GHz	14.25	13.73	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 17.1 GHz	17.25	–	–	
	16.9 to 18 GHz	19.25	–	–	
	18 to 20 GHz	19.25	–	–	
	20 to 26.5 GHz	23.25	–	–	
Noise source ENR					
	Measurement range				
4 to 6.5 dB	0 to 20 dB	± 0.02 dB	± 0.02 dB	± 0.02 dB	
12 to 17 dB	0 to 30 dB	± 0.03 dB	± 0.03 dB	± 0.03 dB	Using internal preamp and RBW ≤ 4 MHz
20 to 22 dB	0 to 35 dB	± 0.03 dB	± 0.03 dB	± 0.03 dB	
Jitter					
		± 0.15 dB	± 0.15 dB	± 0.15 dB	
Instrument uncertainty for gain[4,5]					
	10 MHz to 3.6 GHz	± 0.13 dB	± 0.13 dB	± 0.13 dB	DUT gain range = −20 to +40 dB
	> 3.6 GHz	± 0.13 dB	± 0.13 dB	± 0.13 dB	

Instrument uncertainty for noise figure, 10 MHz to 26.5 GHz[6]

PXA with U7227C preamplifier

	Frequency	PXA full range	PXA + U7227C full range		
VSWR[1]					
	Frequency				
	10 to 100 MHz	1.45	–		
	0.1 to 3.6 GHz	1.45	1.43		
	3.5 to 4 GHz	1.54	1.43		
	4 to 8.4 GHz	1.54	2.32		
	8.3 to 13.6 GHz	1.57	2.32		
	13.5 to 17.1 GHz	1.48	2.32		
	17.0 to 26.5 GHz	1.54	2.32		
		Internal preamp on	**Internal preamp off + U7227C**	**Internal preamp on + U7227C**	**Supplemental information**
Noise figure[2, 3]					
	10 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 GHz	14.25	13.88	6.51	
	4 to 6 GHz	14.25	13.28	6.56	
	6 to 8.4 GHz	14.25	12.61	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	18.46	6.25	
Noise source ENR					
	Measurement range				
4 to 6.5 dB	0 to 20 dB	± 0.02 dB	± 0.02 dB	± 0.02 dB	
12 to 17 dB	0 to 30 dB	± 0.03 dB	± 0.03 dB	± 0.03 dB	Using internal preamp and RBW ≤ 4 MHz
20 to 22 dB	0 to 35 dB	± 0.03 dB	± 0.03 dB	± 0.03 dB	
Jitter					
		± 0.15 dB	± 0.15 dB	± 0.15 dB	
Instrument uncertainty for gain[4, 5]					
	10 MHz to 3.6 GHz	± 0.13 dB	± 0.13 dB	± 0.13 dB	DUT gain range = −20 to +40 dB
	> 3.6 GHz	± 0.13 dB	± 0.13 dB	± 0.13 dB	

Instrument uncertainty for noise figure, 10 MHz to 26.5 GHz[6]

PXA with U7227F preamplifier

	Frequency	PXA full range	PXA + U7227F full range		
VSWR[1]					
	Frequency				
	0.01 to 2 GHz	1.39	–		
	2 to 3.6 GHz	1.39	2.32		
	3.5 to 8.4 GHz	1.50	2.32		
	8.3 to 13.6 GHz	1.31	2.32		
	13.5 to 17.1 GHz	1.33	2.32		
	17.0 to 26.5 GHz	1.34	2.32		
	26.4 to 34.5 GHz	1.41	2.32		
	34.4 to 40 GHz	1.42	2.32		
	40 to 44 GHz	1.42	3.00		
	44 to 50 GHz	1.42	3.57		
		Internal preamp on	Internal preamp off + U7227F	Internal preamp on + U7227F	Supplemental information
Noise figure[2, 3]					
	10 to 100 MHz	13.25	–	–	
	2 to 2.1 GHz	13.25	11.85	10.17	
	2.1 to 3.6 GHz	14.25	12.97	10.20	
	3.5 to 4 GHz	17.25	18.49	10.39	
	4 to 8.4 GHz	17.25	16.48	8.49	
	8.3 to 13.6 GHz	17.25	13.19	8.37	
	13.5 to 17.1 GHz	17.25	15.64	8.31	
	17 to 20 GHz	19.25	16.77	8.42	
	20 to 26.5 GHz	20.25	17.21	8.38	
	26.4 to 30 GHz	21.25	14.85	8.40	
	30 to 34 GHz	23.25	14.92	8.50	
	33 to 37 GHz	26.25	18.63	8.83	
	37 to 40 GHz	29.25	18.01	9.33	
	40 to 43 GHz	31.25	18.39	10.42	
	43 to 44 GHz	31.25	18.19	10.35	
	44 to 46 GHz	31.25	17.93	11.01	Due to U7227F temperature instability, noise figure measurements are not traceable above 44 GHz with the preamp attached.
	46 to 50 GHz	34.25	19.74	11.35	
Noise source ENR					
	Measurement range				
4 to 6.5 dB	0 to 20 dB	± 0.02 dB	± 0.02 dB	± 0.02 dB	
12 to 17 dB	0 to 30 dB	± 0.03 dB	± 0.03 dB	± 0.03 dB	Using internal preamp and RBW ≤ 4 MHz
20 to 22 dB	0 to 35 dB	± 0.03 dB	± 0.03 dB	± 0.03 dB	
Jitter					
		± 0.15 dB	± 0.15 dB	± 0.15 dB	
Instrument uncertainty for gain[4, 5]					
	10 MHz to 3.6 GHz	± 0.19 dB	± 0.19 dB	± 0.19 dB	DUT gain range = −20 to +40 dB
	> 3.6 GHz	± 0.19 dB	± 0.19 dB	± 0.19 dB	

Instrument uncertainty for noise figure, 10 MHz to 26.5 GHz[6]

MXA with U7227A preamplifier

	Frequency	MXA full range	MXA + U7227A full range		
VSWR[1]					
	Frequency				
	10 to 100 MHz	1.52	3.57		
	0.1 to 2 GHz	1.52	1.43		
	2 to 3 GHz	1.52	1.73		
	3 to 3.6 GHz	1.52	1.93		
	3.5 to 4 GHz	1.68	1.93		
	4 to 8.4 GHz	1.68	–		
	8.3 to 13.6 GHz	1.69	–		
	13.5 to 17.1 GHz	1.66	–		
	17.0 to 26.5 GHz	1.66	–		
		Internal preamp on	**Internal preamp off + U7227A**	**Internal preamp on + U7227A**	**Supplemental information**
Noise figure[2, 3]					
	10 to 100 MHz	15.25	12.27	6.40	
	0.1 to 2.1 GHz	15.25	10.59	5.65	
	2.1 to 3.6 GHz	16.25	11.54	5.69	
	3.5 to 4 GHz	16.25	11.38	5.66	
	4 to 6 GHz	16.25	–	–	
	6 to 8.4 GHz	16.25	–	–	
	8.3 to 13.6 GHz	16.25	–	–	
	13.5 to 17.1 GHz	19.25	–	–	
	17 to 18 GHz	22.25	–	–	
	18 to 20 GHz	22.25	–	–	
	20 to 26.5 GHz	27.25	–	–	
Noise source ENR					
	Measurement range				
4 to 6.5 dB	0 to 20 dB	± 0.02 dB	± 0.02 dB	± 0.02 dB	
12 to 17 dB	0 to 30 dB	± 0.03 dB	± 0.03 dB	± 0.03 dB	Using internal preamp and RBW ≤ 4 MHz
20 to 22 dB	0 to 35 dB	± 0.03 dB	± 0.03 dB	± 0.03 dB	
Jitter					
		± 0.15 dB	± 0.15 dB	± 0.15 dB	
Instrument uncertainty for gain[4, 5]					
	10 MHz to 3.6 GHz	± 0.19 dB	± 0.19 dB	± 0.19 dB	DUT gain range = –20 to +40 dB
	> 3.6 GHz	± 0.19 dB	± 0.19 dB	± 0.19 dB	

Instrument uncertainty for noise figure, 10 MHz to 26.5 GHz[6]

MXA with U7227C preamplifier

	Frequency	MXA full range	MXA + U7227C full range		
VSWR[1]					
	Frequency				
	10 to 100 MHz	1.52	–		
	0.1 to 3.6 GHz	1.52	1.43		
	3.5 to 4 GHz	1.68	1.43		
	4 to 8.4 GHz	1.68	2.32		
	8.3 to 13.6 GHz	1.69	2.32		
	13.5 to 17.1 GHz	1.66	2.32		
	17.0 to 26.5 GHz	1.66	2.32		
		Internal preamp on	Internal preamp off + U7227C	Internal preamp on + U7227C	Supplemental information
Noise figure[2, 3]					
	10 to 100 MHz	15.25	–	–	
	0.1 to 2.1 GHz	15.25	11.89	6.71	
	2.1 to 3.6 GHz	16.25	13.14	6.81	
	3.5 to 4 GHz	16.25	13.06	6.79	
	4 to 6 GHz	16.25	12.45	5.87	
	6 to 8.4 GHz	16.25	11.76	4.95	
	8.3 to 13.6 GHz	16.25	11.47	4.71	
	13.5 to 17.1 GHz	19.25	15.06	5.11	
	17 to 18 GHz	22.25	15.77	5.92	
	18 to 20 GHz	22.25	15.37	6.43	
	20 to 26.5 GHz	27.25	21.36	7.65	
Noise source ENR					
	Measurement range				
4 to 6.5 dB	0 to 20 dB	± 0.02 dB	± 0.02 dB	± 0.02 dB	
12 to 17 dB	0 to 30 dB	± 0.03 dB	± 0.03 dB	± 0.03 dB	Using internal preamp and RBW ≤ 4 MHz
20 to 22 dB	0 to 35 dB	± 0.03 dB	± 0.03 dB	± 0.03 dB	
Jitter					
		± 0.15 dB	± 0.15 dB	± 0.15 dB	
Instrument uncertainty for gain[4, 5]					
	10 MHz to 3.6 GHz	± 0.19 dB	± 0.19 dB	± 0.19 dB	DUT gain range = −20 to +40 dB
	> 3.6 GHz	± 0.19 dB	± 0.19 dB	± 0.19 dB	

Instrument uncertainty for noise figure, 10 MHz to 26.5 GHz[6]

EXA with U7227A preamplifier

	Frequency	EXA full range	EXA + U7227A full range		
VSWR[1]					
	Frequency				
	10 to 100 MHz	1.52	3.57		
	0.1 to 2 GHz	1.52	1.54		
	2 to 3 GHz	1.52	1.73		
	3 to 3.6 GHz	1.52	1.93		
	3.5 to 4 GHz	1.68	1.93		
	4 to 8.4 GHz	1.68	–		
	8.3 to 13.6 GHz	1.69	–		
	13.5 to 17.1 GHz	1.66	–		
	17.0 to 26.5 GHz	1.66	–		
		Internal preamp on	Internal preamp off + U7227A	Internal preamp on + U7227A	Supplemental information
Noise figure[2, 3]					
	10 to 100 MHz	17.25	14.79	6.86	
	100 MHz to 2.1 GHz	17.25	12.95	6.00	
	2.1 to 3.6 GHz	18.25	13.17	6.05	
	3.5 to 4 GHz	18.25	13.00	6.01	
	4 to 6 GHz	18.25	–	–	
	7 to 13.6 GHz	19.25	–	–	
	13.5 to 17.1 GHz	21.25	–	–	
	17 to 18 GHz	25.25	–	–	
	18 to 20 GHz	25.25	–	–	
	20 to 26.5 GHz	29.25	–	–	
Noise source ENR					
	Measurement range				
4 to 6.5 dB	0 to 20 dB	± 0.02 dB	± 0.02 dB	± 0.02 dB	
12 to 17 dB	0 to 30 dB	± 0.03 dB	± 0.03 dB	± 0.03 dB	Using internal preamp and RBW ≤ 4 MHz
20 to 22 dB	0 to 35 dB	± 0.03 dB	± 0.03 dB	± 0.03 dB	
Jitter					
		± 0.15 dB	± 0.15 dB	± 0.15 dB	
Instrument uncertainty for gain[4, 5]					
	10 MHz to 3.6 GHz	± 0.19 dB	± 0.19 dB	± 0.19 dB	DUT gain range = –20 to +40 dB
	> 3.6 GHz	± 0.19 dB	± 0.19 dB	± 0.19 dB	

Instrument uncertainty for noise figure, 10 MHz to 26.5 GHz[6]

EXA with U7227C preamplifier

	Frequency	EXA full range	EXA + U7227C full range		
VSWR[1]					
	Frequency				
	10 to 100 MHz	1.52	–		
	0.1 to 3.6 GHz	1.52	1.43		
	3.5 to 4 GHz	1.68	1.43		
	4 to 8.4 GHz	1.68	2.32		
	8.3 to 13.6 GHz	1.69	2.32		
	13.5 to 17.1 GHz	1.66	2.32		
	17.0 to 26.5 GHz	1.66	2.32		
		Internal preamp on	Internal preamp off + U7227C	Internal preamp on + U7227C	Supplemental information
Noise figure[2, 3]					
	10 to 100 MHz	17.25	–	–	
	100 MHz to 2.1 GHz	17.25	14.30	7.08	
	2.1 to 3.6 GHz	18.25	14.82	7.23	
	3.5 to 4 GHz	18.25	14.73	7.20	
	4 to 6 GHz	18.25	14.15	6.33	
	6 to 7 GHz	18.25	13.81	5.53	
	7 to 13.6 GHz	19.25	15.90	5.34	
	13.5 to 17.1 GHz	21.25	21.78	5.66	
	17 to 18 GHz	25.25	21.55	7.24	
	18 to 20 GHz	25.25	21.06	7.51	
	20 to 26.5 GHz	29.25	23.32	8.68	
Noise source ENR					
	Measurement range				
4 to 6.5 dB	0 to 20 dB	± 0.02 dB	± 0.02 dB	± 0.02 dB	
12 to 17 dB	0 to 30 dB	± 0.03 dB	± 0.03 dB	± 0.03 dB	Using internal preamp and RBW ≤ 4 MHz
20 to 22 dB	0 to 35 dB	± 0.03 dB	± 0.03 dB	± 0.03 dB	
Jitter					
		± 0.15 dB	± 0.15 dB	± 0.15 dB	
Instrument uncertainty for gain[4, 5]					
	10 MHz to 3.6 GHz	± 0.19 dB	± 0.19 dB	± 0.19 dB	DUT gain range = −20 to +40 dB
	> 3.6 GHz	± 0.19 dB	± 0.19 dB	± 0.19 dB	

Instrument uncertainty for noise figure, 10 MHz to 26.5 GHz[6]

EXA with U7227F preamplifier

	Frequency	EXA full range	EXA + U7227F full range		
VSWR[1]					
	Frequency				
	0.01 to 2 GHz	1.52	–		
	2 to 3.6 GHz	1.52	2.32		
	3.5 to 8.4 GHz	1.68	2.32		
	8.3 to 13.6 GHz	1.69	2.32		
	13.5 to 17.1 GHz	1.66	2.32		
	17.0 to 26.5 GHz	1.66	2.32		
	26.5 to 40 GHz	–	2.32		
	40 to 44 GHz	–	3.00		
		Internal preamp on	Internal preamp off + U7227F	Internal preamp on + U7227F	Supplemental information
Noise figure[2, 3]					
	10 to 1.2 GHz	14.25	–	–	
	1.2 to 2.1 GHz	15.25	–	–	
	2 to 2.1 GHz	15.25	12.65	10.27	
	2.1 to 3.6 GHz	16.25	13.49	10.32	
	3.5 to 4 GHz	18.25	19.36	10.49	
	4 to 7 GHz	18.25	15.91	8.65	
	7 to 20 GHz	18.25	15.91	8.34	
	20 to 26.5 GHz	20.25	17.21	8.38	
	26.5 to 32 GHz	23.25	19.69	8.56	
	32 to 34 GHz	23.25	19.27	8.50	
	33.9 to 40 GHz	26.5	23.67	8.72	
	40 to 44 GHz	30.25	22.81	10.11	
Noise source ENR					
Measurement range					
4 to 6.5 dB	0 to 20 dB	± 0.02 dB	± 0.02 dB	± 0.02 dB	
12 to 17 dB	0 to 30 dB	± 0.03 dB	± 0.03 dB	± 0.03 dB	Using internal preamp and RBW ≤ 4 MHz
20 to 22 dB	0 to 35 dB	± 0.03 dB	± 0.03 dB	± 0.03 dB	
Jitter					
		± 0.15 dB	± 0.15 dB	± 0.15 dB	
Instrument uncertainty for gain[4, 5]					
	10 MHz to 3.6 GHz	± 0.19 dB	± 0.19 dB	± 0.19 dB	DUT gain range = –20 to +40 dB
	> 3.6 GHz	± 0.19 dB	± 0.19 dB	± 0.19 dB	

Instrument uncertainty for noise figure, 10 MHz to 26.5 GHz[6]

CXA with U7227A preamplifier

	Frequency	CXA full range	CXA + U7227A full range	
VSWR[1]				
	Frequency			
	10 to 100 MHz	3.0	3.57	
	0.1 to 2 GHz	3.0	1.54	
	2 to 3 GHz	3.0	1.73	
	3 to 4 GHz	3.0	1.93	
	4 to 7.5 GHz	3.0	–	
	7.5 to 26.5 GHz	2.5	–	

		Internal preamp on	Internal preamp off + U7227A	Internal preamp on + U7227A	Supplemental information
Noise figure[2, 3]					
	10 to 100 MHz	17.25	13.92	6.86	
	0.1 to 1.5 GHz	17.25	16.80	6.06	
	1.5 to 3 GHz	19.25	16.10	6.37	
	3 to 4 GHz	19.25	15.64	6.24	
	4 to 6 GHz	19.25	–	–	
	6 to 7.5 GHz	22.25	–	–	
	7.5 to 13.6 GHz	22.25	–	–	
	13.6 to 18 GHz	24.25	–	–	
	18 to 20 GHz	24.25	–	–	
	20 to 24 GHz	27.25	–	–	
	24 to 26.5 GHz	37.25	–	–	
Noise source ENR					
	Measurement range				
4 to 6.5 dB	0 to 20 dB	± 0.05 dB	± 0.05 dB	± 0.05 dB	
12 to 17 dB	0 to 30 dB	± 0.05 dB	± 0.05 dB	± 0.05 dB	Using internal preamp and RBW ≤ 4 MHz
20 to 22 dB	0 to 35 dB	± 0.1 dB	± 0.1 dB	± 0.1 dB	
Jitter					
		± 0.15 dB	± 0.15 dB	± 0.15 dB	DUT gain range = –20 to +40 dB
Instrument uncertainty for gain[4, 5]					
		± 0.20 dB	± 0.20 dB	± 0.20 dB	

Instrument uncertainty for noise figure, 10 MHz to 26.5 GHz[6]

CXA with U7227C preamplifier

	Frequency	CXA full range	CXA + U7227C full range		
VSWR[1]					
	Frequency				
	10 to 100 MHz	3.0	–		
	0.1 to 3 GHz	3.0	1.43		
	3 to 4 GHz	3.0	1.43		
	4 to 7.5 GHz	3.0	2.32		
	7.5 to 26.5 GHz	2.5	2.32		
		Internal preamp on	Internal preamp off + U7227C	Internal preamp on + U7227C	Supplemental information
Noise figure[2, 3]					
	10 to 100 MHz	17.25	–	–	
	0.1 to 1.5 GHz	17.25	18.04	7.12	
	1.5 to 3 GHz	19.25	17.67	7.55	
	3 to 4 GHz	19.25	17.43	7.47	
	4 to 6 GHz	19.25	16.88	6.62	
	6 to 7.5 GHz	22.25	18.36	7.10	
	7.5 to 13.6 GHz	22.25	18.76	6.36	
	13.6 to 18 GHz	24.25	22.53	6.75	
	18 to 20 GHz	24.25	22.04	7.10	
	20 to 24 GHz	27.25	22.98	7.96	
	24 to 26.5 GHz	37.25	32.27	14.75	
Noise source ENR					
	Measurement range				
4 to 6.5 dB	0 to 20 dB	± 0.05 dB	± 0.05 dB	± 0.05 dB	
12 to 17 dB	0 to 30 dB	± 0.05 dB	± 0.05 dB	± 0.05 dB	Using internal preamp and RBW ≤ 4 MHz
20 to 22 dB	0 to 35 dB	± 0.1 dB	± 0.1 dB	± 0.1 dB	
Jitter					
		± 0.15 dB	± 0.15 dB	± 0.15 dB	DUT gain range = –20 to +40 dB
Instrument uncertainty for gain[4, 5]					
		± 0.20 dB	± 0.20 dB	± 0.20 dB	

Instrument uncertainty for noise figure, 10 MHz to 26.5 GHz[6]

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 $NF_{sys} = 10*Log(F_{preamp} + (F_{analyzer} - 1)/G_{preamp})$. 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 Agilent 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 Agilent 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
NFA: www.keysight.com/find/NFA_X-Series_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
– Online version enables you to sweep on almost all the relevant parameters to see their impact on measurement uncertainty. Access the online version of the NFUC through: www.keysight.com/find/nfuc

Software Licensing and Instrument Configuration

Choose from two license types::

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

You Can Upgrade!

Options can be added after your initial purchase.
All of our X-Series application options are license-key up-gradeable.

UP GRADE

N9069C noise figure X-Series measurement application

Model-Option	Description, license type
N9069C-3FP	Noise figure measurement fixed perpetual
N9069C-3TP	Noise figure measurement transportable perpetual

Hardware Configuration

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

- UXA N9040B
- PXA N9030B
- MXA N9020B
- EXA N9010B
- CXA N9000B

Capability	Instrument Option	Benefit
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	Required: For maximizing the measurement sensitivity to meet specifications

The following NFA X-Series Noise Figure Analyzers are supported:
- N8973B
- N8974B
- N8975B
- N8976B

The NFA-X-Series comes standard with the fine step attenuator, precision frequency reference, full band preamplifier, noise floor extension, and U7227 USB preamplifier so no additional options are required.

Noise source

346 Series noise sources work with the full range of Keysight noise figure solutions. They are categorized by frequency coverage as well as excess noise ratio (ENR). The SNS noise sources replicate the ENR output and frequency coverage of the 346 Series noise sources, however with the SNS 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.

The U7227A/C/F USB preamplifiers, used with an X-Series signal analyzer reduces uncertainty of Y-factor noise figure measurements up to 50 GHz.

Noise source	Frequency range	ENR
346A	10 MHz to 18 GHz	5 to 7 dB
346B	10 MHz to 18 GHz	14 to 16 dB
346C	10 MHz to 26 GHz	12 to 17 dB
346CK01	1 GHz to 50 GHz	7 to 20 dB
346CK40	1 GHz to 40 GHz	3 to 14 dB
Q347B	33 GHz to 50 GHz	6 to 13 dB
R347B	26.5 GHz to 40 GHz	10 to 13 dB
N4000A	10 MHz to 18 GHz	4.6 to 6.5 dB
N4001A	10 MHz to 18 GHz	14 to 16 dB
N4002A	10 MHz to 26 GHz	12 to 17 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

Specification	U7227A	U7227C	U7227F
Frequency	10 MHz to 4 GHz	100 MHz to 26.5 GHz	2 GHz to 50 GHz
Gain (dB)	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)	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)
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

Additional Information

Measurement, user's and programming guides can be found on the product Web page in the document library: **www.keysight.com/find/n9069c**

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

Keysight N4000A, N4001A, N4002A SNS Series Noise Sources 10 MHz to 26.5 GHz - Technical Overview, literature number 5980-0288E

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

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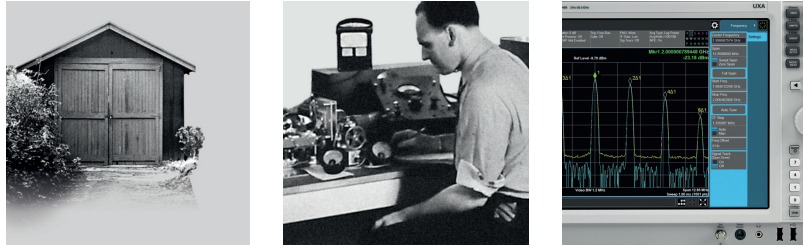
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