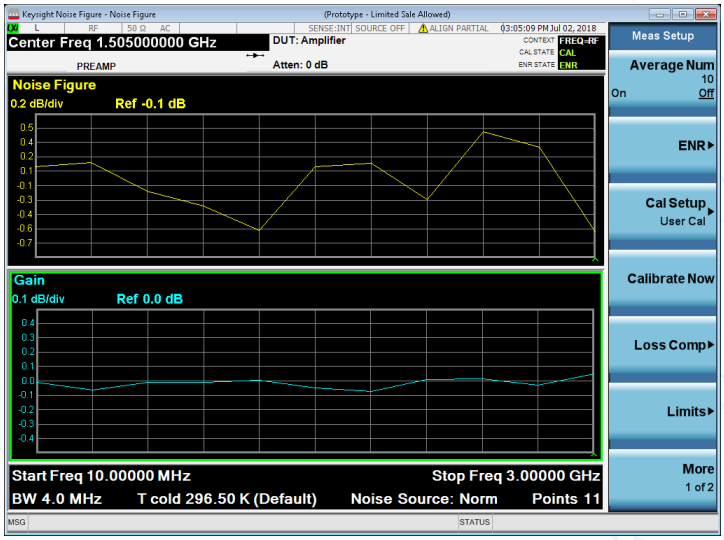
TECHNICAL OVERVIEW

Noise Figure
X-Series Measurement App, Traditional UI N9069EM0D

- Characterize noise figure and gain of connectorized devices and system blocks with graphic, meter, and table views
- User-definable sweep time and noise source settling time
- Fully-specified measurements with optional internal preamp; improved specifications with external USB preamp
- 50 GHz internal uncertainty calculator
- Noise figure measurements to 110 GHz (Option 526 or greater required) with Keysight Technologies, Inc. K-Series block downconverters
- Flexible licensing provides the option of using perpetual or time based licenses with one or multiple signal analyzers



KEYSIGHT TECHNOLOGIES

Noise Figure Measurement Application

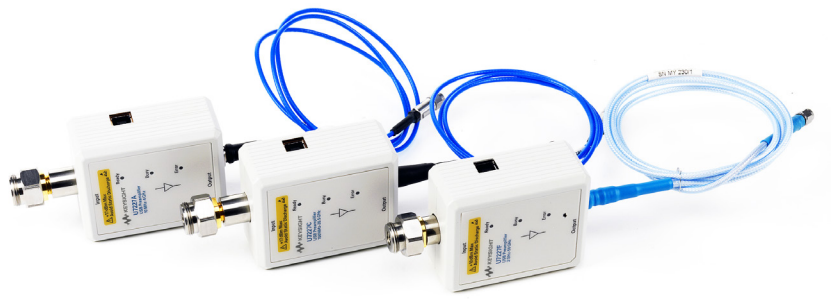
Noise figure is one of the fundamental parameters that differentiates one system, amplifier, or transistor from another. To minimize the problems resulting from noise generated in receiver systems, engineers can either make a weak signal stronger, or reduce the noise of that system or its individual components. Keysight's N9069EM0D noise figure measurement application offers development engineers a simple tool to make accurate and repeatable noise figure measurements. Pair this measurement application with an Keysight X-Series signal analyzer for fully specified results up to 26.5 GHz on the CXA, CXA-m MXA and MXE, up to 44 GHz on the EXA, and up to 50 GHz on the PXA. 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, X-Series signal analyzers or the MXE EMI receiver 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.

The U7227A/C/F USB preamps are available to reduce the uncertainty of Y-factor noise figure measurements to 44 GHz. With these preamps and an X-Series signal analyzer, you can obtain better noise figure measurements than with a dedicated noise figure analyzer such as the N8973/ 4/5A.

When using this application on an X-Series signal analyzer or MXE EMI receiver, engineers will also benefit from full RF signal analysis capabilities in one instrument. In addition, the noise figure measurement application is code-compatible with previous Keysight noise figure solutions where hardware and measurements are the same. The application can be configured for remote programming via USB, LAN, or GPIB—all of which are standard for X-Series.



Key Specifications

Definitions

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

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 gain, see the Noise Figure Measurement Guide, literature number N9069-90006.

Performance specifications

N9030A PXA with U7227A preamplifier		Specifications			
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	Using internal preamp and RBW ≤ 4 MHz
12 to 17 dB	0 to 30 dB	± 0.03 dB	± 0.03 dB	± 0.03 dB	
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]

N9030A PXA with U7227C preamplifier	Specifications			
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	Using internal preamp and RBW ≤ 4 MHz
12 to 17 dB 0 to 30 dB	± 0.03 dB	± 0.03 dB	± 0.03 dB	
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]

N9030A PXA with U7227F preamplifier	Specifications			
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	Using internal preamp and RBW ≤ 4 MHz
12 to 17 dB 0 to 30 dB	± 0.03 dB	± 0.03 dB	± 0.03 dB	
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]

N9020A MXA with U7227A preamplifier	Specifications			
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	Using internal preamp and RBW ≤ 4 MHz
12 to 17 dB	0 to 30 dB	± 0.03 dB	± 0.03 dB	± 0.03 dB	
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]

N9020A MXA with U7227C preamplifier	Specifications			
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	Using internal preamp and RBW ≤ 4 MHz
12 to 17 dB 0 to 30 dB	± 0.03 dB	± 0.03 dB	± 0.03 dB	
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]

N9010A EXA with U7227A preamplifier	Specifications			
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	Using internal preamp and RBW ≤ 4 MHz
12 to 17 dB	0 to 30 dB	± 0.03 dB	± 0.03 dB	± 0.03 dB	
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]

N9010A EXA with U7227C preamplifier	Specifications			
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	Using internal preamp and RBW ≤ 4 MHz
12 to 17 dB	0 to 30 dB	± 0.03 dB	± 0.03 dB	± 0.03 dB	
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]

N9010A EXA with U7227F preamplifier	Specifications			
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	Using internal preamp and RBW ≤ 4 MHz
12 to 17 dB 0 to 30 dB	± 0.03 dB	± 0.03 dB	± 0.03 dB	
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]

N9000A CXA with U7227A preamplifier	Specifications			
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	Using internal preamp and RBW ≤ 4 MHz
12 to 17 dB 0 to 30 dB	± 0.05 dB	± 0.05 dB	± 0.05 dB	
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]

N9000A CXA with U7227C preamplifier		Specifications			
	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	Using internal preamp and RBW ≤ 4 MHz
12 to 17 dB	0 to 30 dB	± 0.05 dB	± 0.05 dB	± 0.05 dB	
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]

M9290A CXA-m		Specifications	
	Frequency	CXA-m full range	
VSWR[1]			
	Frequency		
	10 MHz to 13.6 GHz	2.2	
	13.6 to 26.5 GHz	2.5	
		Internal preamp on	Supplemental information
Noise figure[2, 3]			
	10 MHz to 4.5 GHz	17.25	
	4.5 to 9.5 GHz	20.25	
	9.5 to 13 GHz	21.25	
	13 to 14.5 GHz	19.25	
	14.5 to 19.3 GHz	24.25	
	19.3 to 23 GHz	25.25	
	23 to 24 GHz	27.25	
	24 to 26.5 GHz	34.25	
Noise source ENR			
	Measurement range		
4 to 6.5 dB	0 to 20 dB	± 0.05 dB	
12 to 17 dB	0 to 30 dB	± 0.05 dB	
20 to 22 dB	0 to 35 dB	± 0.1 dB	
Jitter			
		± 0.15 dB	DUT gain range = –20 to +40 dB
Instrument uncertainty for gain[4, 5]			
		± 0.17 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 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 for gain is characterized to the 95th percentile above 3.6 GHz.

[6] "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.

Note: Data subject to change

Computing measurement uncertainty

Keysight provides several versions of a noise figure uncertainty calculator (NFUC). The spreadsheet version gives the user 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/nfuc

Noise figure and VSWR of the measurement depend on the measurement configuration used and also the gain of the DUT.

For more information about measurement uncertainty, the Using the U7227-Series USB Preamps for Noise Figure Measurements user guide is available.

instructions on calculating noise figure measurement uncertainty using the USB preamplifiers can be found in the U7227-Series user guide.

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

PXA: www.keysight.com/find/pxa_specifications
MXA: www.keysight.com/find/mxa_specifications
EXA: www.keysight.com/find/exa_specifications
CXA: www.keysight.com/find/cxa_specifications
MXE: www.keysight.com/find/mxe_specifications
PXIe CXA-m: www.keysight.com/find/cxa-m_specifications
PXIe VSA up to 6 GHz: www.keysight.com/find/m9391a
PXIe VSA up to 50 GHz: www.keysight.com/find/m9393a
PXIe VXT: www.keysight.com/find/m9421a

Ordering Information

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- **Perpetual:** License can be used in perpetuity.
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UP GRADE

Noise figure measurement application (N9069EM0D)

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

One month software support subscription extensions[3]

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

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

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Hardware Configurations

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

Software Models & Options

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

Hardware Configuration

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

Benchtop:

- PXA N9030A
- MXA N9020A
- MXE N9038A
- EXA N9010A
- CXA N9000A

PXIe:

- VSA (6 GHz) M9391A
- VSA (50 GHz) M9393A
- VXT M9421A
- CXA-m M9290A

N90x0A X-Series signal analyzer

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

M9391/93A PXIe VSA vector signal analyzer

Description	Model-Option	Additional information
Frequency range 3 or 6 GHz	M9391A-F03, or F06	One required for M9391A
Frequency range 8.4, 14, 18, or 27 GHz Frequency extension to 43.5 or 50 GHz	M9393A-F08, F14, F18, or F27 M9393A-FRZ or FRX	One required for M9393A 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

M9420/21A PXIe VXT vector transceiver

Description	Model-Option	Additional information
Frequency range 3.8 or 6 GHz	M9420A/M9421A-504, or 506	One required
Analysis bandwidth 40, 80 or 160 MHz	M9420A/M9421A-B40/B80/B1X	One required
Memory 256 or 512 MSa	M9420A/M9421A-M02/M05	One required
Half duplex port	M9420A/M9421A-HDX	Optional
High output power	M9420A/M9421A-1EA	Optional

M9290A CXA-m PXIe signal analyzer

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

Noise source offerings

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 Series of noise sources, or smart noise sources, can be used in conjunction with the X-Series signal analyzers, NFA, and ESA spectrum analyzer. 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, reduce uncertainty of Y-factor noise figure measurements up to 44 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
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
U1831C	10 MHz to 26.5 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

Related Literature

Noise Figure Measurement Accuracy: The Y-Factor Method, Application Note 57-2, literature number 5952-3706E

N9069A & W9069A Noise Figure X-Series Measurement Application Self-Guided Demonstration, literature number 5990-9835EN

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

Web

Product pages:
www.keysight.com/find/N9069D

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

X-Series and modular signal analyzers:
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