Agilent N4000A, N4001A, N4002A SNS Series Noise Sources 10 MHz to 26.5 GHz

Technical Overview

Advances in Noise Figure Accuracy

N4000A
Used for low noise figure devices or devices sensitive to mismatch in the 10 MHz to 18 GHz range

N4001A
Used for general purpose measurements in the 10 MHz to 18 GHz range

N4002A
Used for measurements in the 10 MHz to 26.5 GHz range

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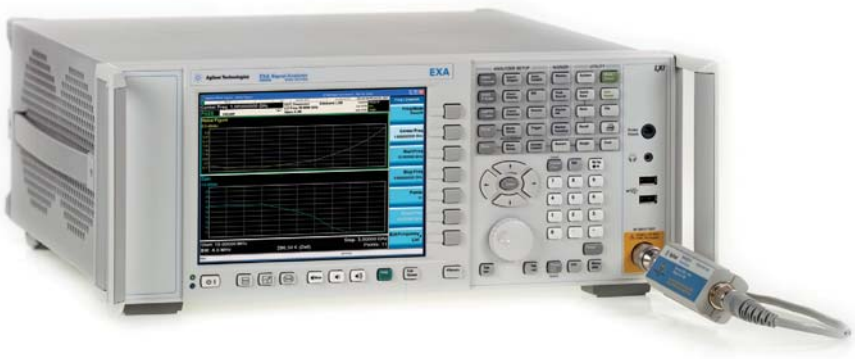
Noise sources designed to meet specific needs



The Agilent SNS Series of noise sources work in conjunction with

- NFA Series noise figure analyzers
- X-Series signal analyzers
- ESA E-Series spectrum analyzers

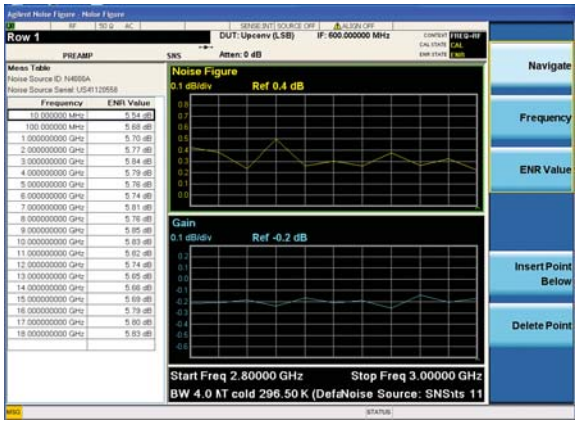
To simplify measurement set-up and improve accuracy these noise sources automatically download electronically stored calibration data to the compatible Agilent noise figure measuring analyzers. The noise sources also have the capability to automatically measure their own temperature so that compensation can be applied to the calibration data. These capabilities increase the overall reliability and accuracy of noise figure measurements.

SNS Series key features and benefits

- Automatic download of ENR data to the analyzer speeds overall setup time.
- Electronic storage of Excess Noise Ratio (ENR) calibration data decreases the opportunity for user error.
- Temperature sensing improves measurement accuracy, leading to tighter specification of device performance.

The N4000A and N4001A, which cover the 10 MHz to 18 GHz frequency range, come with an APC 3.5 (m) connector as standard, and offer the option of a Type-N (m) connector.

The N4002A, which covers the frequency range 10 MHz to 26.5 GHz, has an APC 3.5 (m) connector as standard.



Automatically downloaded ENR data table in the NFA noise figure analyzers, X-Series Signal Analyzers and ESA E-Series spectrum analyzers with noise figure capability

N4000A for low noise figure or mismatch sensitive devices up to 18 GHz

The N4000A is designed to accurately measure devices with low noise figure, or devices whose gain is especially sensitive to small changes in source impedance. This includes most GaAs FETs. The N4000A maintains the same impedance whether turned on or off. By maintaining the same impedance at the input to the device under test (DUT) gain changes are reduced. These gain changes can often masquerade as DUT noise and cause noise figure measurement errors.

The ENR of this noise source is nominally 6 dB from 10 MHz to 18 GHz. DUTs with noise figures up to 20 dB can be accurately and reliably measured with this device. The N4000A noise source has a choice of connectors, with an APC 3.5 (m) as standard and type N (m) as an option.

N4001A for general purpose measurements from 10 MHz to 18 GHz

The N4001A noise source is ideal for general purpose use with a low reflection coefficient and a nominal ENR of 15 dB from 10 MHz to 18 GHz. DUT with noise figures up to 30 dB can be measured accurately and reliably with this device. The N4001A has a selection of connectors, with an APC 3.5 (m) as standard and type N (m) as an option.

N4002A for measurements up to 26.5 GHz

The N4002A noise source is designed to measure DUT noise figures reliably and accurately up to 30 dB from 10 MHz up to 26.5 GHz accurately and reliably. This noise source comes with an APC 3.5 (m) connector.

Accurate noise power

The output of a noise source, usually given in terms of Excess Noise Ratio (ENR), must be known in order to make accurate noise figure measurements. Any uncertainty in the ENR transfers into uncertainty of the measured noise figure, dB for dB. Agilent provides accurate ENR calibration data with each noise source. ENR uncertainty and reflection coefficients at each frequency point are provided as well.

The following is an example of calibration data for an N4001A noise source:

Model No : N4001A
Option Installed : N/A
Serial No : MY53400007
Description : SNS noise source
Temperature : (23 ± 1) °C
Humidity : (20 to 70)% RH

Frequency (MHz)	ENR (dB)	ENR UNC (dB)	Reflection coef. ON (Mag)	Reflection coef. ON (Phase deg)	Reflection coef. OFF (Mag)	Reflection coef. OFF (Phase deg)
10	14.873	0.088	0.022	–88.113	0.037	–44.812
100	15.060	0.087	0.005	–159.277	0.025	–17.945
1000	14.741	0.083	0.019	109.546	0.028	–166.271
2000	14.731	0.102	0.015	–28.482	0.030	64.734
3000	14.611	0.082	0.020	160.052	0.019	–76.318
4000	14.598	0.078	0.031	47.546	0.028	115.927
5000	14.513	0.100	0.026	–58.964	0.039	–3.191
6000	14.504	0.083	0.020	168.358	0.036	–131.360
7000	14.466	0.083	0.023	49.737	0.041	95.579
8000	14.461	0.086	0.018	–39.016	0.046	–17.949
9000	14.634	0.077	0.007	–116.483	0.036	–134.563
10000	14.713	0.074	0.007	–157.454	0.026	100.876
11000	14.708	0.079	0.014	110.707	0.016	–28.480
12000	14.835	0.106	0.024	18.129	0.010	117.865
13000	14.804	0.085	0.024	–64.569	0.031	–4.004
14000	14.957	0.109	0.008	166.651	0.027	–108.113
15000	15.103	0.088	0.027	–30.952	0.010	52.508
16000	15.231	0.104	0.060	–119.578	0.057	–93.483
17000	15.143	0.092	0.077	152.783	0.093	165.788
18000	15.049	0.100	0.062	65.410	0.084	66.951

The importance of noise source reflection coefficient

Two aspects of noise source reflection coefficient are important to note:

- A non-zero reflection coefficient contributes to re-reflections between the DUT and the source. The reflections cause uncertainty in the noise power emerging from the source. The measured noise figure, furthermore, refers to the actual noise source impedance rather than the desired 50 Ω value. The low reflection coefficient of Agilent SNS Series noise sources can keep this uncertainty under 0.1 dB.
- The change in reflection coefficient between On and Off can cause DUT Gain variations which, in turn, can cause noise figure measurement errors. This problem is effectively eliminated by the N4000A, whose complex reflection coefficient change is specified to be less than 0.01.

Choosing between the N4000A and the N4001A

The key difference between the N4000A and the N4001A noise sources is the nominal 6 dB ENR of the N4000A whereas the N4001A has a nominal 15 dB ENR.

Consider the 6 dB ENR noise source when

- The DUT is especially sensitive to source impedance changes at its input
- There is a need to measure very low noise figures
- The noise figure does not exceed 20 dB

The N4001A is well suited to general-purpose measurements up to 18 GHz, whereas the N4000A is better suited to making measurements on lower noise devices or devices which are sensitive to changes in input impedance. The N4000A contains additional internal attenuation, which provides greater isolation at its output, and its output impedance is less affected by the ON/OFF condition. There is a benefit of using a N4000A rather than a N4001A with an added attenuator. The extra attenuaton in the N4000A is included in its calibration and is fully traceable.

The factory and field calibration of the N4000A are not as good as that of N4001A because of its lower ENR, resulting in 0.005 dB higher ENR uncertainty.

SNS Series noise source specifications

Specifications

The specifications are performance standards or limits against which the noise source may be tested. These specifications for the noise source are only valid if the analyzer has been allowed to meet its specified warm up time. Specifications are valid at ambient temperature 23°C only (296 K).

Instrument model	Frequency range	ENR range
N4000A	10 MHz to 18 GHz	4.5 - 6.5 dB
N4001A	10 MHz to 18 GHz	14 - 16 dB
N4002A	10 MHz to 26.5 GHz	12 - 17 dB

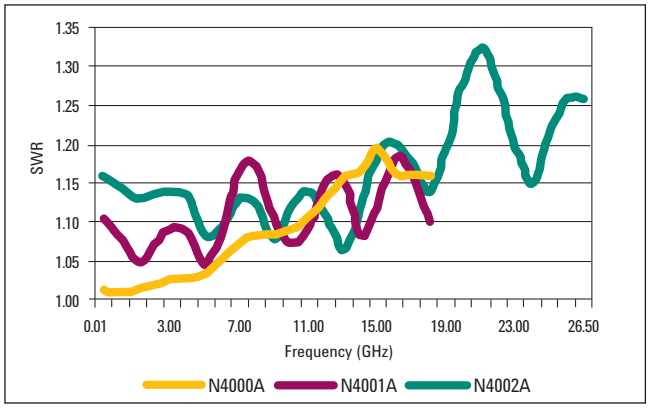


Figure 1. Characteristic SWR at 23°C

Instrument model	Frequency range (GHz)	Max standing wave ratio (SWR)	Reflection coefficient (Rho) (ρ)
N4000A	0.01 - 1.5	< 1.04:1	0.03
	1.5 - 3.0	< 1.04:1	0.03
	3.0 - 7.0	< 1.13:1	0.06
	7.0 - 18.0	< 1.22:1	0.10
N4001A	0.01 - 1.5	< 1.15:1	0.07
	1.5 - 3.0	< 1.15:1	0.07
	3.0 - 7.0	< 1.20:1	0.09
	7.0 - 18.0	< 1.25:1	0.11
N4002A	0.01 - 1.5	< 1.22:1	0.10
	1.5 - 3.0	< 1.22:1	0.10
	3.0 - 7.0	< 1.22:1	0.10
	7.0 - 18.0	< 1.25:1	0.11
	18.0 - 26.5	< 1.35:1	0.15

For N4000A, the maximum change in complex reflection coefficient between noise source ON and OFF states: 0.01

Supplemental characteristics

Supplemental characteristics are not specifications but are typical characteristics included as additional information for the user.

Temperature sensing accuracy

ENR variation with temperature: < 0.01 dB/°C for 30 MHz to 26.5 GHz

Range:	0 to 55°C
Resolution:	0.25°C
Accuracy:	±1° at 25°C
	±2° over 0°C to 55°C

ENR Uncertainties

ENR values are given at cardinal frequency points over the frequency range of each noise source. These values are stored within the noise sources' internal EEPROM and documented in the calibration report.

The uncertainty analysis for the calibration of the noise sources is in accordance with the ISO/TAG4 guide. The uncertainty data reported on the calibration report is the expanded uncertainty (U(Y)) with 95% confidence level and a coverage factor of 2.

The dominant contributor to the expanded uncertainty (U(Y)) comes from the uncertainties provided by the National Standards Institute through which the calibration traces. Agilent therefore reserves the right to change the overall expanded uncertainties based on changes in uncertainty values within the National Standards Institutes.

Uncertainties are valid at ambient temperature 23°C ± 1°C (296 K) only. Example plots of ENR uncertainty versus each cardinal frequency point are shown in Figure 2. These graphs show the improvements in processes and uncertainty analysis in 2013.

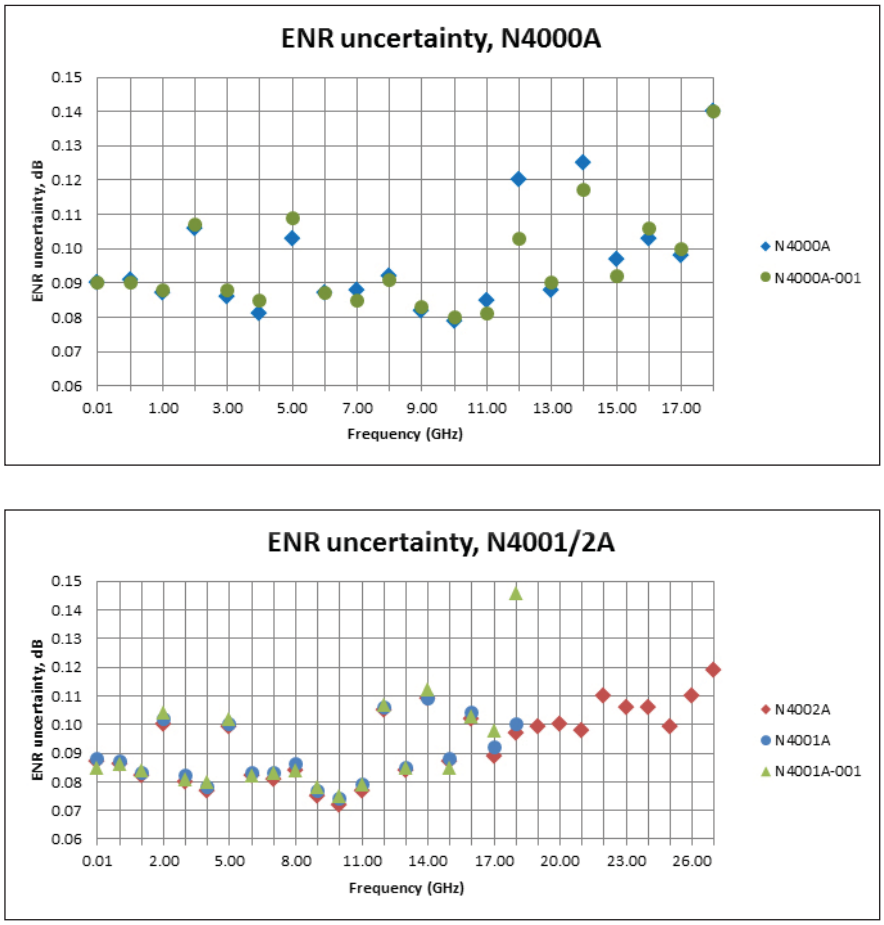


Figure 2. Example ENR uncertainties at the cardinal frequencies (late 2013 data)

Connector care for the APC-3.5 (m) connector

The APC-3.5 (m) connector is designed for instrumentation applications requiring long life, low reflection coefficient, and good mating capabilities with SMA connectors.

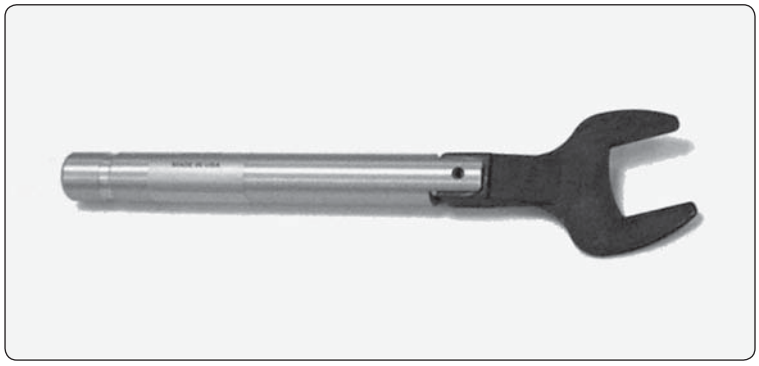
The APC-3.5 (m) can achieve a life expectancy of over 1000 connections if precautions as listed below are taken:

1. Use a torque wrench set to the recommended torque.
2. Tighten the nut only, to prevent the connectors rotating with respect to each other. Friction causes rapid wear of the conducting surfaces.
3. Clean connectors after every 10 connections.
4. Mate with APC-3.5 connectors in good condition.

Casual use of the connector can reduce the life expectancy of APC-3.5 (m) connectors to fewer than 200 connections. Below is a list of several actions that may also reduce the life expectancy of the APC-3.5 (m).

1. Estimating the torque with an ordinary wrench.
2. Twisting the noise source body (accidentally or otherwise) during final tightening or when loosening.
3. Frequent mating with worn-out SMA connectors. This can be a problem with frequently used accessories.

The APC-3.5 (m) connector used on the SNS Series of noise sources has an extra-large nut to make it easier to tighten without applying torque to the noise source body. A 20 mm torque wrench is also available from Agilent for this application. Please contact your local Agilent representative for ordering information.



Agilent 20 mm torque wrench 8710-1764

Ordering information

Products

N4000A SNS Series noise source, 10 MHz to 18 GHz, nominal ENR 6 dB
N4001A SNS Series noise source, 10 MHz to 18 GHz, nominal ENR 15 dB
N4002A SNS Series noise source, 10 MHz to 26.5 GHz, nominal ENR 15 dB

All of these noise sources are provided with an APC 3.5 (m) connector as standard

Options

N400xA-002	5-foot (1.5 m) SNS noise source cable is a default option as it is required to make the SNS function. Unselect this option if you already own a noise source cable.

The following option is available with the N4000A and the N4001A:

Connector

N400xA-001	Type-N (m) connector
N400xA-100	APC 3.5 (m) connector

Service options

Warranty and service
Standard warranty is 3 years.

R-51B-001-5Z	Warranty Assurance Plan - Return to Service Center - 5 years

Calibration

R-50C-011-3	Calibration Assurance Plan - Return to Service Center - 3 years
R-50C-011-5	Calibration Assurance Plan - Return to Service Center - 5 years
R-50C-011-MU-3	Calibration + Uncertainties - 3 years
R-50C-011-MU-5	Calibration + Uncertainties - 5 years
R-50C-021-3	ANZI Z540-1-1994 Calibration - 3 years
R-50C-021-5	ANZI Z540-1-1994 Calibration - 5 years

Recommended accessories

The SNS Smart Noise Source Series requires a compatible cable and adaptor to enable their use. The 11730A is selected as a default option for every SNS; however, customers may choose to unselect this option or order the 11730B or 11730C separately.

11730A: 5-foot (1.5 m) power sensor and SNS noise source cable
(included as a default option with every SNS)
11730B: 10-foot (3.0m) power sensor and SNS noise source cable
11730C: 20-foot (6.1m) power sensor and SNS noise source cable

A good quality adaptor must be used to connect the SNS Series noise source to the input of the NFA Series noise figure analyzer. Agilent provides a suitable connector upon purchasing an NFA. These adaptors are also available separately.

83059B precision 3.5 mm coaxial adaptor

Agilent recommends a torque wrench for use with the large sized (20 mm) APC 3.5 (m) connector nut found on the Agilent SNS Series noise sources. Agilent also recommends a torque wrench for use with the 5/16" connector on the female to female adaptor.

8710-1764: 20 mm torque wrench
8710-1765: 5/16" torque wrench

Noise Figure Literature from Agilent

Agilent instruments are backed up with a full spectrum of literature and support offerings. A detailed listing follows.

N/W9069A - X Series Noise Figure Measurement Application - Technical Overview, Literature number 5989-6536EN

Noise Figure Selection Guide, Literature number 5989-8056EN

NFA Series - Noise Figure Analyzers - NFA Series - Data Sheet Literature number 5980-0164E

Fundamentals of RF and Microwave Noise Figure Measurements, Application Note 57-1, Literature number 5952-8255E

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

10 Hints for Making Successful Noise Figure Measurements, Application Note 57-3, Literature number 5980-0288E

Key web resources

For more information on Agilent's SNS Series noise sources, visit:
www.agilent.com/find/SNS

For the latest information on Agilent noise figure solutions, visit:
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