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

Technical Overview



KEYSIGHT TECHNOLOGIES

Unlocking Measurement Insights

Noise Sources Designed to Meet Specific Needs



The Keysight Technologies, Inc. SNS Series of noise sources work in conjunction with

- NFA Series noise figure analyzers
- X-Series signal analyzers

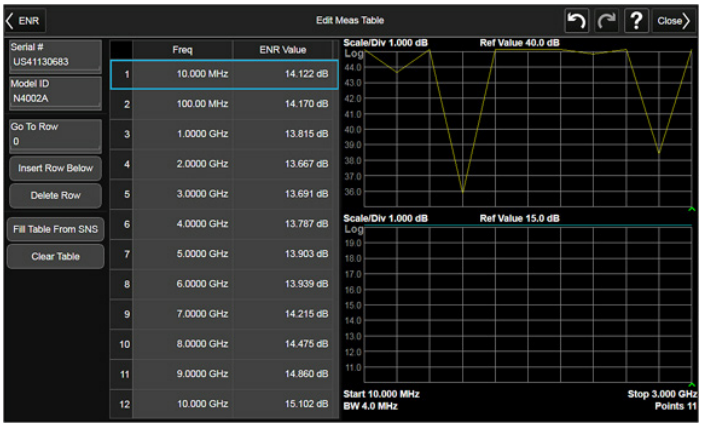
To simplify measurement set-up and improve accuracy these noise sources automatically download electronically stored calibration data to the compatible Keysight noise figure measuring analyzers. The noise sources also have the capability to automatically measure their own temperature so that compensation 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 downloads ENR data from an SNS Series noise source into any NFA Series or any X-Series signal analyzer

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

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 FET's. 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.

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's 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.

N4002A for Measurements Up to 26.5 GHz

The N4002A noise source was 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 connector as standard.

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. Keysight 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:

ENR Data File
Created by N8975A NFA Series Noise Figure Analyzer
Serial Number GB40390000 Firmware Revision A.01.01
13:37:07 Mar 28, 2001
Format is: Frequency (Hz), ENR (dB), ENR Unc (dB), # On Refl.Mag (lin), On Refl.Phase (deg),
Off Refl.Mag (lin), Off Refl.Phase (deg) , # On Refl.Mag Unc (lin), On Refl.Phase Unc (deg),
Off Refl.Mag Unc (lin), Off Refl.Phase Unc (deg)
[Filetype ENR]
[Version 1.1]
[Serialnumber US41240152]
[Model N4001A]
[Option 001]
[Caldate 20000727]
[Calduedate 20010727]
[Placeofcal EPSGQ]
[Trackingnum 10]
[Temperature 296.5K]
[Humidity 65%]
[Current 36272]

10000000,	15.281,	0.193,	0.0450,	–136.0,	0.0450,	–136.0,	0.0030,	–6.0,	0.0070,	+6.0,
100000000,	15.291,	0.190,	0.0358,	+168.0,	0.0358,	+168.0,	0.0040,	+4.6,	0.0050,	–4.6,
1000000000,	15.118,	0.151,	0.0398,	+39.6,	0.0398,	+39.6,	0.0100,	+4.5,	0.0067,	+1.5,
2000000000,	14.999,	0.168,	0.0377,	0.168,	0.0377,	–85.7,	0.0056,	+0.9,	0.0086,	+1.9,
3000000000,	14.879,	0.172,	0.0267,	+150.6,	0.0267,	+150.6,	0.0080,	–9.2,	0.0090,	–1.2,
4000000000,	14.795,	0.173,	0.0130,	–18.1,	0.0130,	–18.1,	0.0013,	+16.0,	0.0063,	+10.0,
5000000000,	14.818,	0.179,	0.0359,	+169.5,	0.0359,	+169.5,	0.0024,	–9.3,	0.0035,	–0.3,
6000000000,	14.846,	0.181,	0.0556,	+63.7,	0.0556,	+63.7,	0.0041,	+10.3,	0.0067,	–4.3,
7000000000,	14.895,	0.180,	0.0430,	–37.0,	0.0430,	–27.0,	0.0079,	–2.3,	0.0049,	–2.3,
8000000000,	15.016,	0.198,	0.0232,	–160.3,	0.0232,	–160.3,	0.0091,	–3.8,	0.0053,	–1.8,
9000000000,	15.134,	0.201,	0.0122,	+71.4,	0.0122,	+71.4,	0.0037,	+17.3,	0.0057,	+7.3,
10000000000,	15.253,	0.194,	0.0080,	+116.2,	0.0080,	+116.2,	0.0048,	–1.4,	0.0056,	–5.4,
11000000000,	15.249,	0.243,	0.0241,	+65.7,	0.0241,	+65.7,	0.0059,	+1.5,	0.0049,	+44.5,
12000000000,	15.349,	0.240,	0.0196,	+8.8,	0.0196,	+8.8,	0.0057,	+3.2,	0.0077,	+2.2,
13000000000,	15.383,	0.188,	0.0217,	–5.4,	0.0217,	–5.4,	0.0062,	–6.9,	0.0045,	–1.9,
14000000000,	15.355,	0.178,	0.0228,	–66.6,	0.0228,	–66.6,	0.0075,	+11.2,	0.0065,	+1.2,
15000000000,	15.367,	0.187,	0.0141,	+141.6,	0.0141,	+141.6,	0.0036,	–3.2,	0.0029,	–1.2,
16000000000,	15.421,	0.182,	0.0251,	+6.4,	0.0251,	+6.4,	0.0030,	+7.2,	0.0042,	–1.2,
17000000000,	15.418,	0.174,	0.0242,	–100.5,	0.0242,	–100.5,	0.0048,	–2.7,	0.0050,	+9.7,
18000000000,	15.464,	0.179,	0.0183,	+124.4,	0.0183,	+124.4,	0.0098,	–1.1,	0.0100,	+9.1,

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 Keysight 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 N40001A 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. It is less affected by the ON/OFF condition that is the output impedance of the N4001A. There is a benefit of using a N4000A rather than a N40001A with an added attenuator. The extra attenuaton in the N4000A is included in its calibration and is fully traceable.

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 of 60 minutes. Specifications are valid at ambient temperature 23 ± 5°C .

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

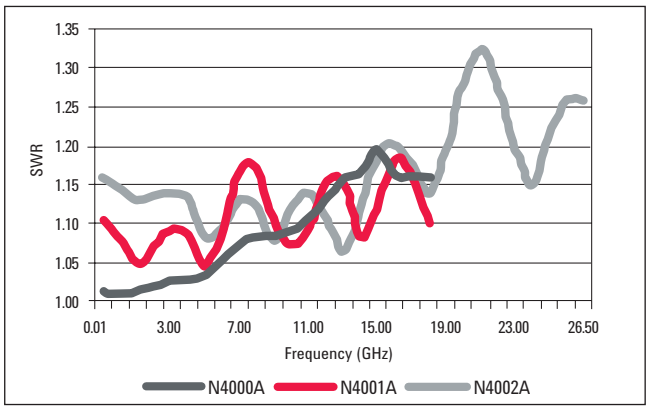


Figure 1. Characteristic SWR at 23°C

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

Supplemental Characteristics Temperature Sensing Accuracy

Maximum change in complex reflection coefficient between noise source ON and OFF states: 0.01

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

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

Characteristic ENR (U(Y)) Specification

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. This uncertainty analysis is valid for APC 3.5mm and Type-N (Option 001) connector types.

Instrument model	Frequency range	ENR uncertainty (± dB)[1]
N4000A	0.01 - 1.5	0.16
	1.5 - 3.0	0.15
	3.0 - 7.0	0.15
	7.0 - 18.0	0.16
N4001A	0.01 - 1.5	0.14
	1.5 - 3.0	0.13
	3.0 - 7.0	0.13
	7.0 - 18.0	0.16
N4002A	0.01 - 1.5	0.15
	1.5 - 3.0	0.13
	3.0 - 7.0	0.13
	7.0 - 18.0	0.15
	18.0 - 26.5	0.22

1. Characteristic values are met or bettered by 90% of instruments with 90% confidence.

The uncertainty for each noise source can be unique to that noise source. The uncertainty will typically vary by less than 0.01 dB at any frequency between different noise sources produced in the same year when first produced. Subsequent calibrations must be performed at suitably capable calibration vendors in order to keep the uncertainties similar.

The standard level of calibration for the SNS series is Option A1R (calibration against a 1-level removed reference standard). Another choice is Option APR (calibration against a primary reference standard).

For Option A1R, performance can only be matched with a Standards Lab Calibration, available from the Roseville Standards Lab at Keysight. For Option APR, performance can only be matched by the National Physical Laboratory (NPL) in the UK.

Using the appropriate calibration level should result in similar uncertainties to the original production uncertainties. These will mostly be within 0.01 dB of the original uncertainties, but they will vary with each calibration because they include the repeatability observed on each device. Uncertainties for newly produced devices include population repeatabilities instead of individual device repeatabilities, and thus vary little between devices of the same model and option configuration.

Figures 2 and 3 show example uncertainties for standard (option A1R) production noise sources, as of the end of 2013. This time period is after significant changes were made in the uncertainties from better understanding of the error sources and improvements in the references from the National Metrology Institute used, NPL. If NPL performance changes in the future, Keysight uncertainties will follow those changes.

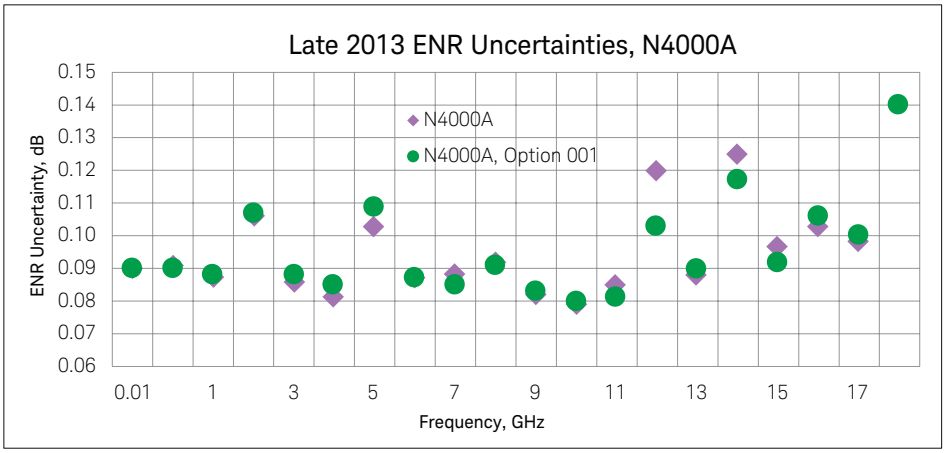


Figure 2. Example ENR versus frequency for the N4000A model.

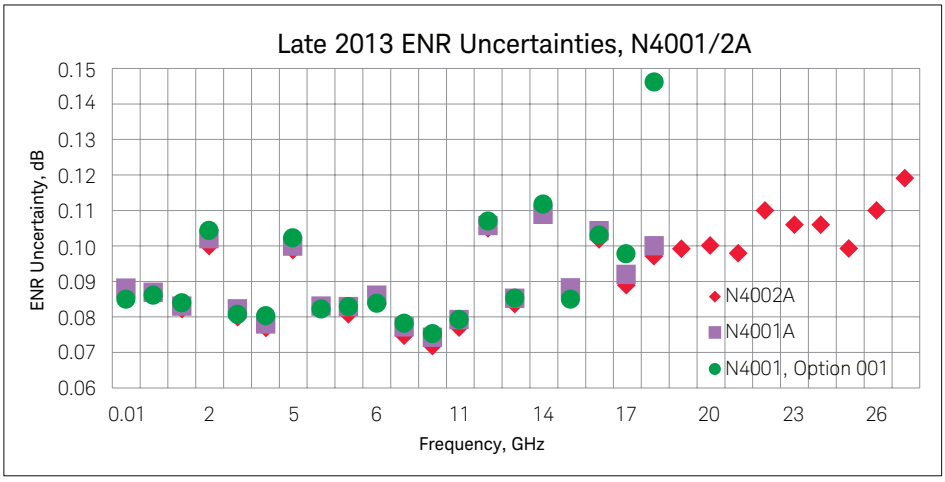


Figure 3. Example ENR versus frequency for the N4001A and N4002A models.

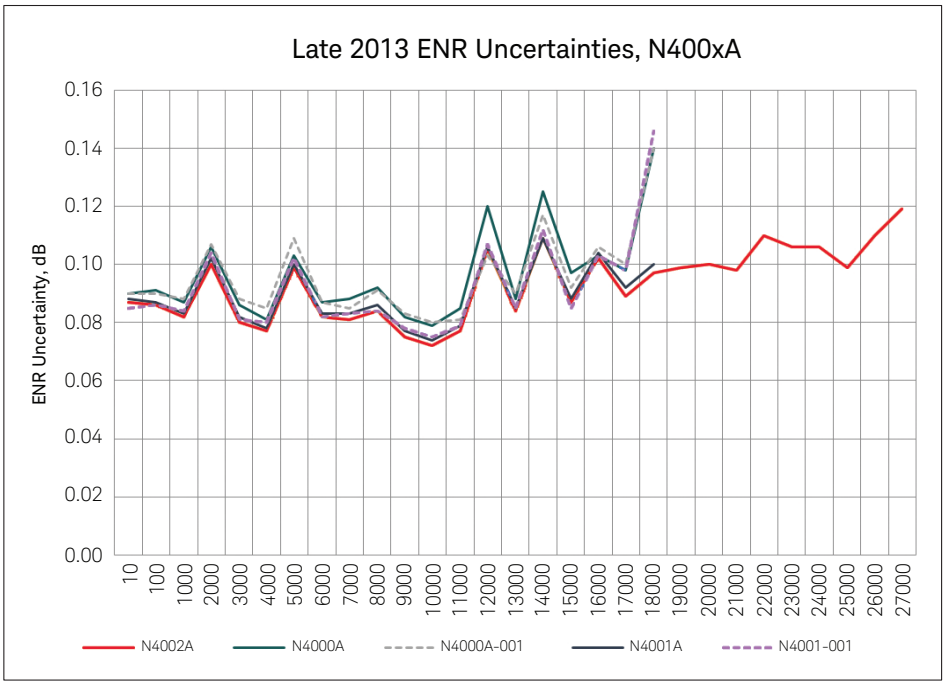


Figure 4. Characteristic ENR plot versus cardinal frequency points.

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.

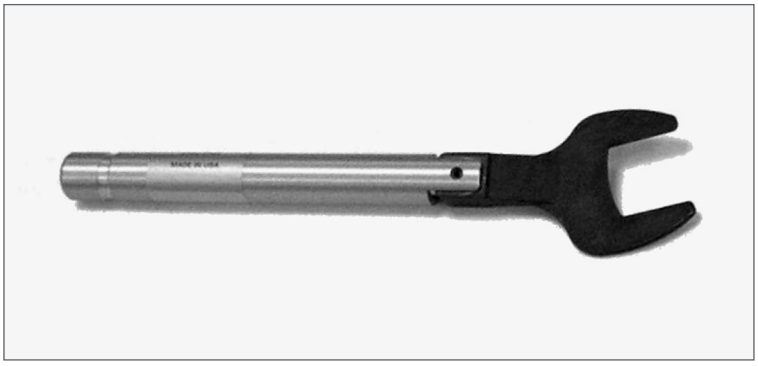
The APC-3.5 (m) can achieve a life expectancy of over 1000 connections if precautions as listed below are taken:

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).

5. Estimating the torque with an ordinary wrench.
6. Twisting the noise source body (accidentally or otherwise) during final tightening or when loosening.
7. 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 Keysight for this application. Please contact your local Keysight representative for ordering information.



Keysight 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
For 3 years, order 36 months of R-51B. Standard warranty is 12 months.

R-51B	Return to Keysight warranty and service plan

Calibration[1]
For 3 years, order 36 months of the appropriate calibration plan shown below.

R-50C-001	Standard calibration plan
R-50C-002	Standard compliant calibration plan

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. Keysight provides a suitable connector upon purchasing an NFA. These adaptors are also available separately.

83059B precision 35 mm coaxial adaptor

Keysight recommends a torque wrench for use with the large sized (20 mm) APC 3.5 (m) connector nut found on the Keysight SNS Series noise sources. Keysight 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 Keysight

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

Noise Figure Selection Guide,
Literature number 5989-8056EN

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

Optimizing RF and Microwave Spectrum Analyzer Dynamic Range, Application Note 1315, Literature number 5968-4545E

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

Key Web Resources

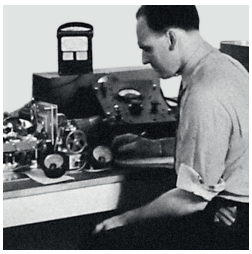
For the latest information on Keysight noise figure solutions, visit our web page at: **www.keysight.com/find/nf**

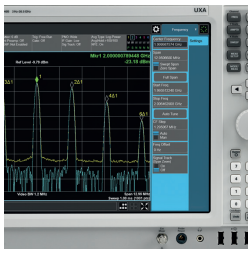
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From Hewlett-Packard through Agilent to Keysight

For more than 75 years, we've been helping you unlock measurement insights. Our unique combination of hardware, software and people can help you reach your next breakthrough. Unlocking measurement insights since 1939.







1939 THE FUTURE

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