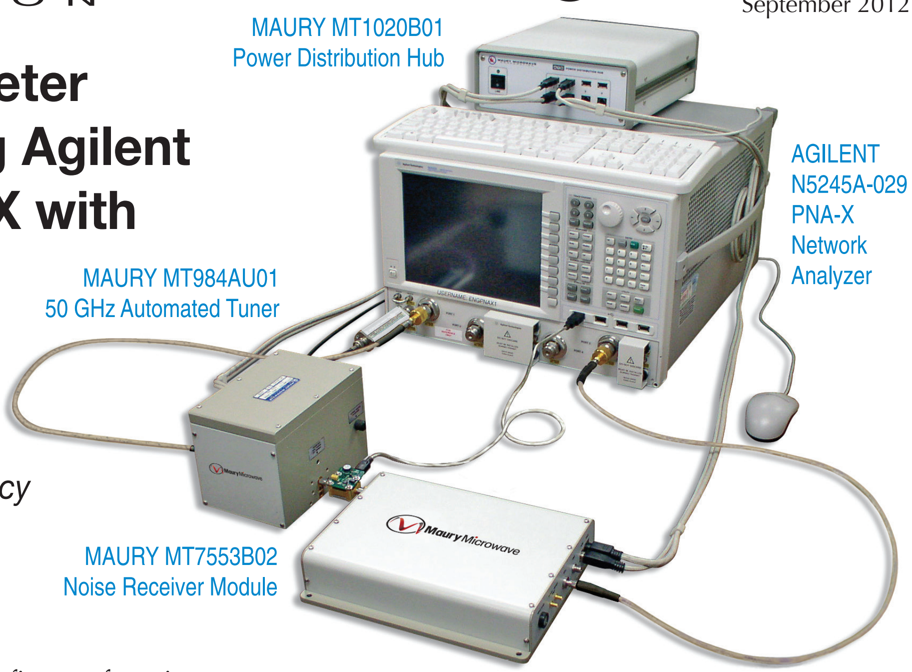
September 2012

50 GHz Noise Parameter Measurements Using Agilent N5245A-series PNA-X with Noise Option 029

Features & Benefits

- *Turnkey noise parameters*
- *Improved measurement accuracy*
- *Improved measurement speed*



Typical 8–50 GHz noise parameter measurement setup using a Maury MT7553B02 Noise Receiver Module, a Maury MT984AU01 Automated Tuner and Agilent's PNA-X.

Introduction

The most common measure of noise is the figure-of merit referred to as Noise Figure. Noise figure is usually measured in a 50Ω environment and seeks to quantify the signal-to-noise degradation caused by an amplifier. Noise figure, however, varies with the source impedance presented to the amplifier so it is not sufficient to fully characterize your devices. The variations due to source impedance can be characterized and represented in terms of noise parameters. It is essential to understand the noise parameters of your devices, especially when designing low-noise amplifiers using mismatched devices.

Noise Parameters are comprised of four distinct characteristics, Fmin the minimum noise figure of the transistor, Γopt the optimum impedance at which Fmin occurs (in real and imaginary), and Rn the equivalent series resistance of the transistor.

In theory, any four controlled impedances Γs can be presented to the transistor and the corresponding noise figures F measured in order to satisfy equation

$$F = F_{min} + \frac{4\,R_n}{Z_o}\;\frac{|\Gamma_s - \Gamma_{opt}|^2}{|1+\Gamma_{opt}|^2(1-|\Gamma_s|^2)}$$

and solve four simultaneous equations for four unknowns.

Practically, the impedances selected for Γs should be in the range of Γopt.

Measurement Hardware

The Agilent N524x-series PNA-X is the only instrument of its kind to include an embedded electronic tuner capable of presenting Low-Γ impedances to the device under test.

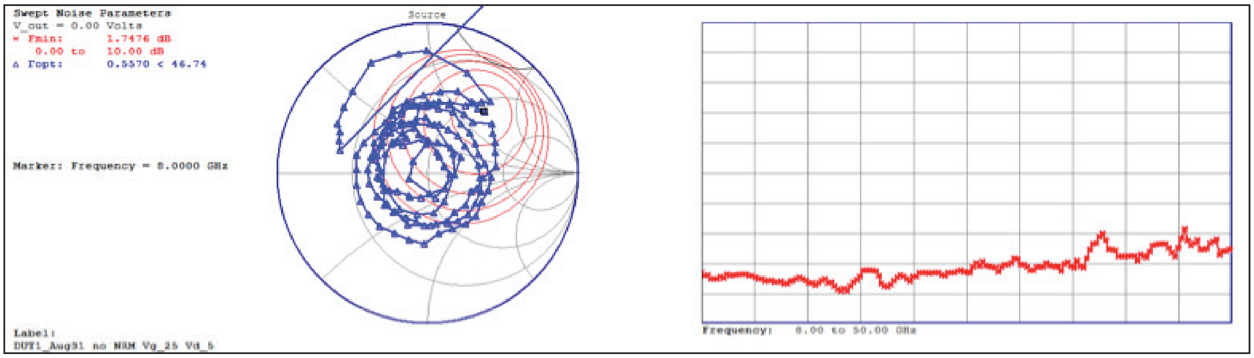
When measuring a near-50Ω transistor, the electronic tuner may be sufficient in presenting impedances to solve the unknown equations and determine noise parameters. For non-50Ω transistors, the embedded electronic tuner is bypassed and an external automated impedance tuner is used to present impedances closer to Γopt.

The PNA-X is also the only instrument to combine a vector receiver with a dedicated and optimized noise receiver. The sensitivity of the noise receiver is critical in determining the noise figure F by accurately measuring the noise power contribution of the transistor. The accuracy of the noise measurement is directly related to the second-stage noise figure of the noise receiver, the lower the better. While it is possible to directly use the noise receiver of the PNA-X, the second-stage noise figure can be reduced by 5-6 dB with the addition of an external noise receiver module (NRM).

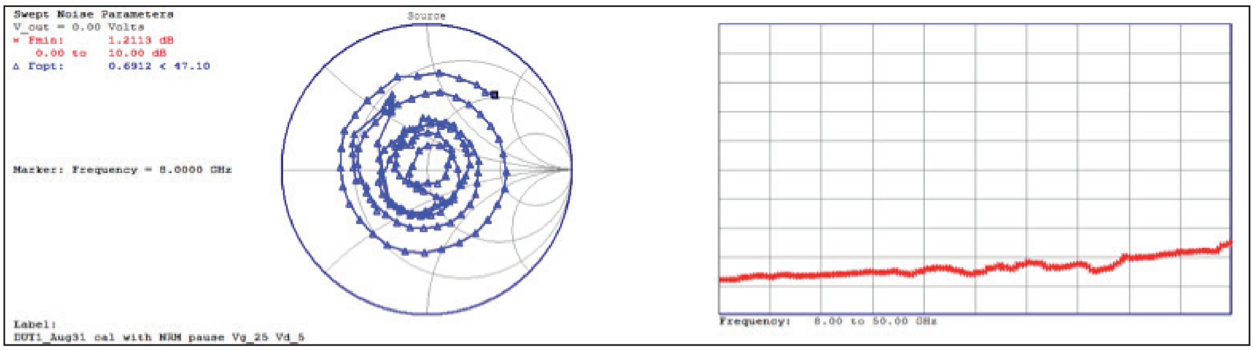
Speed and Accuracy Improvements

Maury Microwave has developed a new ultra-fast noise parameter measurement method (patent pending) that improves overall calibration and measurement time by a factor of 100X-400X, bringing measurements that once took tens or hundreds of hours down to tens of minutes. Two key features contribute to this breakthrough speed improvement: 1)The tuner is characterized with one set of states (physical tuner positions) that are selected to give

2900 Inland Empire Blvd. • Ontario, California 91764-4804
Tel: 909-987-4715 • Fax: 909-987-1112 • http://www.maurymw.com



Wideband noise parameter measurement between 8 GHz and 50 GHz using PNA-X ***without*** *additional NRM*



Wideband noise parameter measurement between 8 GHz and 50 GHz using PNA-X ***with*** *additional NRM*

reasonable impedance spread over the frequency band of interest; and 2) the noise power measurement is swept over the frequency range at each state, so the tuner only moves to each position once. This takes advantage of the fast sweep capability of modern instruments, and saves time by minimizing tuner movement.

The new method improves noise parameter measurement speed by two orders of magnitude, and produces data that is smoother, with less scatter than the traditional method. Measurement at ultra-high speed eliminates temperature drift, and use of a VNA with an internal noise receiver simplifies the setup and makes it much more stable and consistent. The ultra-high speed makes it practical to always do a full in-situ calibration to minimize errors, measure more frequencies for a better view of scatter and cyclical errors, and use smoothing with more confidence. The higher frequency density also enhances accuracy by reducing shifts due to aliasing.

Conclusion

The industry's most accurate mmW noise parameters can be obtained by combining Agilent Technologies' N5245A-series PNA-X with Maury Microwaves MT984AU01 automated impedance tuner, MT7553B02 noise receiver module, and MT993-series ATS software suite. The turnkey solution is capable of measuring wideband noise parameters up to 50 GHz with improved speed and accuracy.

Reference documents:

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4T-085 — *MT7553 Noise Receiver Modules;* Maury Microwave Product Data Sheet.

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