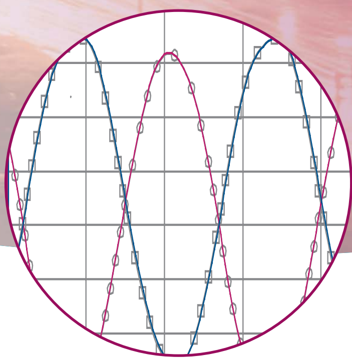
Solutions for

Characterizing and Designing Linear/Nonlinear Active Devices

Accurately characterizing devices' nonlinear behavior

Application Note



Overview

With the proliferation of high data rate wireless communications, R&D engineers and scientists are being challenged to research and design components and systems which provide voice, video, IP, and more in a fast, compact, power-efficient format. This requires pushing semiconductor devices to their performance limits and, increasingly, into their nonlinear regions of operation. Nonlinear device behavior can be especially problematic in the telecommunications industry, contributing significantly to information interference and a reduction in effective bandwidth. Dealing with nonlinearity demands new measurement methodologies that go far beyond today's linear S-parameters which fail to provide engineers with the capabilities to accurately model, simulate and improve the design flow of new product technology.

Problem

The goal for R&D engineers and scientists working in the telecommunications industry today is clear: efficiently and accurately simulate and design active components (e.g., amplifiers and frequency doublers). Accomplishing this goal requires accurate characterization of a device's linear and nonlinear behavior, as well as an accurate and predictable simulation environment covering this behavior. Traditionally, interoperable solutions combining modeling, simulation and measurement have not been available for fully nonlinear components and systems. Engineers rely on limited S-parameter information and are forced to perform extensive and costly empirical-based iteration of designs, adding substantial time and cost to the design process. A new design methodology can now make designing active devices and components deterministic. By allowing engineers to model, simulate and design with significant reduction in design iterations, it dramatically speeds time to market for products with increased accuracy and therefore better specifications.

Agilent Technologies

Solution

A new design methodology from Agilent Technologies, based on X-parameters, X-parameter device models and nonlinear vector network analyzer measurements, enables fast and accurate characterization and design of active devices and components. X-parameters are a mathematically rigorous superset of S-parameters, applicable to nonlinear (as well as linear) components under large and small signal conditions. They enable the characterization and hierarchical design of chains of nonlinear components (e.g., multi-stage power amplifiers and multi-chip modules) and RF systems (e.g., amplifiers and mixers) which are commonly used in communications applications. By measuring X-parameters, R&D engineers and scientists can accurately characterize and gain insight into a device's nonlinear behavior.

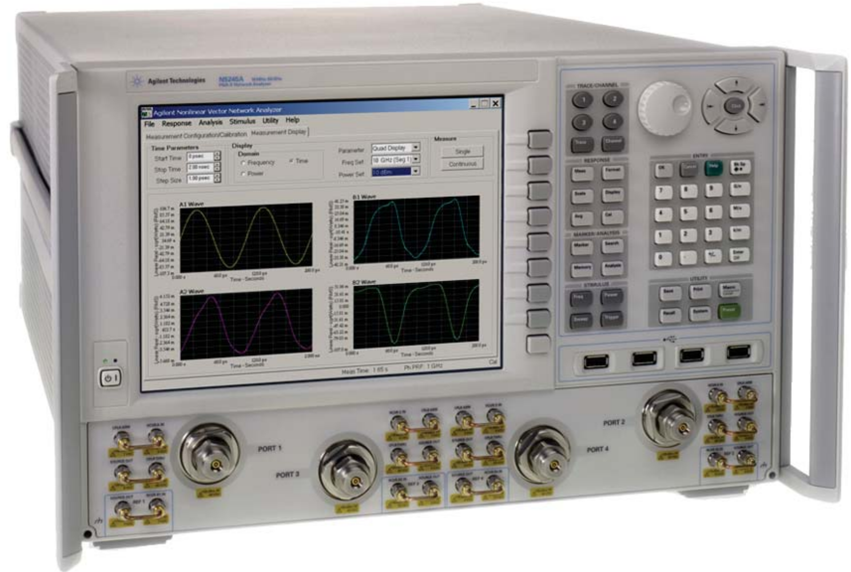


FIGURE 1: *Agilent's NVNA software, for use with the PNA-X microwave network analyzer, establishes a new industry standard in RF nonlinear network analysis from 10 MHz to 50 GHz.*

Using Agilent's Nonlinear Vector Network Analyzer (NVNA) -- based on Agilent's PNA-X network analyzer technology -- X-parameters can be quickly and accurately measured (Figure 1). This information is then used to create X-parameter models that can be imported into Agilent's Advanced Design System (ADS) simulator (Figure 2). Once imported, these models are used to simulate actual linear and nonlinear component behavior. Together, the NVNA and ADS simulator form an automated, interoperable measurement and simulation system for predictable design of nonlinear components.

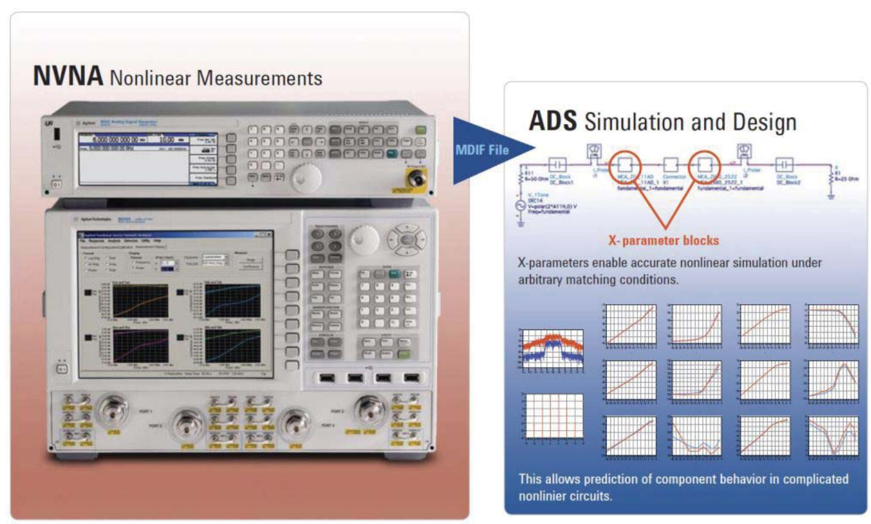


FIGURE 2: *Deterministically measure and view X-parameters with Agilent's NVNA and ADS.*

X-parameters, ADS and the NVNA can be used to reconstruct time domain waveforms, optimize performance parameters such as ACPR, EVM and PAE, design multi-stage components and systems under varying inter-stage match conditions, and optimize nonlinear system performance. By providing a fast, accurate and powerful approach for the design of active devices, these solutions completely eliminate the need for limited S-parameter information or costly, time consuming design iterations. The time saved can be much better spent designing the most competitive products possible.

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Handset Amplifier Example

Using the NVNA, X-parameters and the ADS simulator, it is a straightforward process to improve the performance (PAE and output power) of an amplifier being designed for use in a handset. The process results in a significant reduction in measurement test time and engineering time, and saves substantial design costs.

X-parameters are first measured by the NVNA and then modeled in ADS. Accurate efficiency contours for PAE and output power can then be simulated directly in ADS from the X-parameter model (Figure 3). Inter-stage matching coefficients are directly generated for optimization of the component. By employing this method, measurement test times and engineering time are significantly reduced, and substantial cost savings realized.

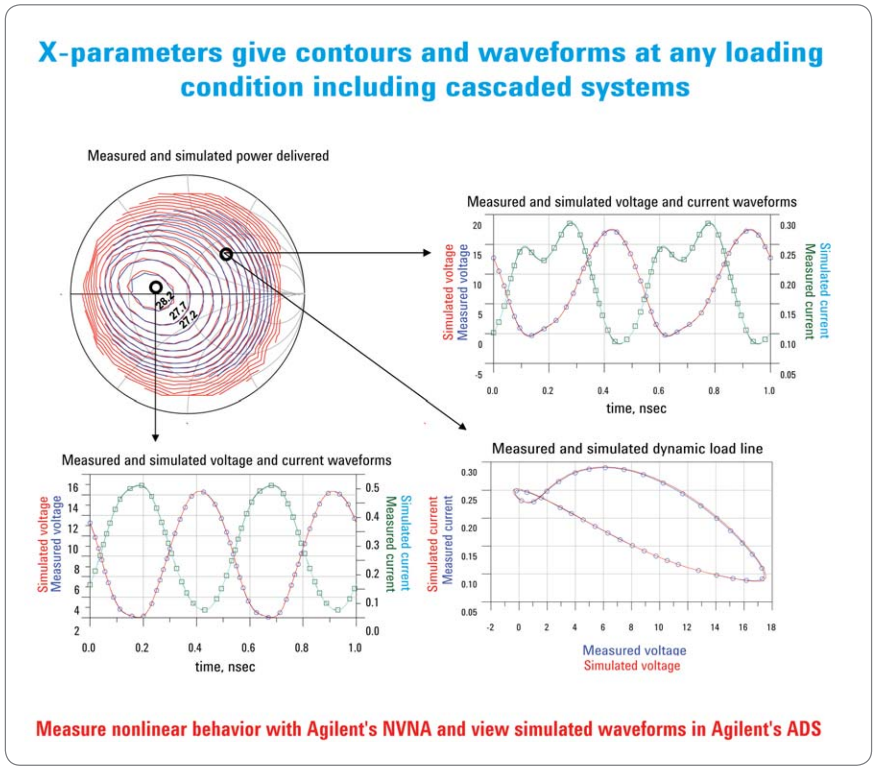
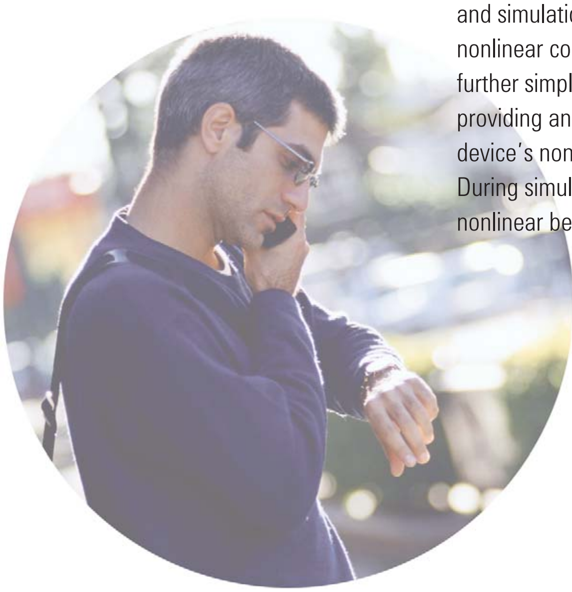


FIGURE 3: *X-parameters give contours and waveforms at any loading condition including cascaded systems.*

Summary of Results

The inefficient, time-consuming and expensive way of designing active devices and components using limited S-parameter information is greatly improved by making use of an interoperable measurement and simulation environment for designing nonlinear components. X-parameters help further simplify this design process by providing an accurate representation of a device's nonlinear (and linear) behavior. During simulation the device's linear/nonlinear behavior can be fully optimized.



POWERED *The Power to Get to Market Faster*

The Power of X

The Agilent PNA-X Microwave Network Analyzer with the NVNA software is a key product in Agilent's comprehensive *Power of X* suite of test products. These products grant engineers the power to gain greater design insight, speed manufacturing processes, solve tough measurement problems, and get to market ahead of the competition.

Offering the best combination of speed and scalability, and created and supported by renowned worldwide measurement experts, Agilent's X products are helping engineers bring innovative, higherper-forming products to emerging markets around the globe.

To learn more about Agilent's suite of X products please visit:
www.agilent.com/find/powerofx.

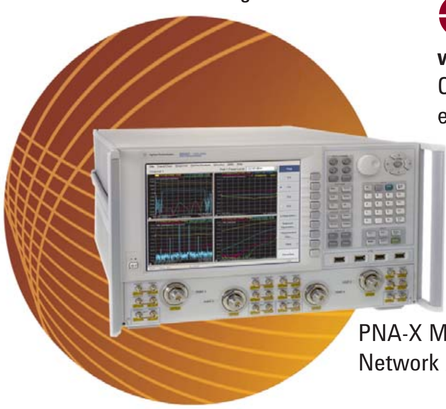
Related applications

- Predictable linear/nonlinear component characterization
- Optimize for maximum output power and PAE
- Accurate and predictable simulation of cascaded components
- Linearization techniques

Related products

- PNA-X Microwave Network Analyzer
- N5181A MXG Analog Signal Generator
- N5182A MXG Vector Signal Generator
- NVNA options:
  - Option 510, Nonlinear Component Characterization
  - Option 514, Nonlinear X-parameters
  - Option 518, Nonlinear Pulse Envelope Domain
  - Option 520, Arbitrary Load Impedance X-parameters

N5181A MXG Analog Signal Generator
N5182A MXG Vector Signal Generator



PNA-X Microwave Network Analyzer

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