X-Parameter Load-Pull Using Agilent NVNA and Focus Tuners

X-parameters represent a new category of nonlinear network parameters for high-frequency design and were developed and introduced by Agilent Technologies as functionality included in Nonlinear Vector Network Analyzer (NVNA), and Advanced Design System (ADS). X-parameters are an extension of S-parameters that can be used to characterize the nonlinear behavior of an active device under different operating conditions. It is a multi-dimensional look-up table that is constructed based on nonlinear measurement data.

Focus fundamental or harmonic tuners can be used with Agilent NVNA to measure X-Parameters of device at different match conditions, or X-parameter load pull. Fig.1 shows the block diagram of the setup.
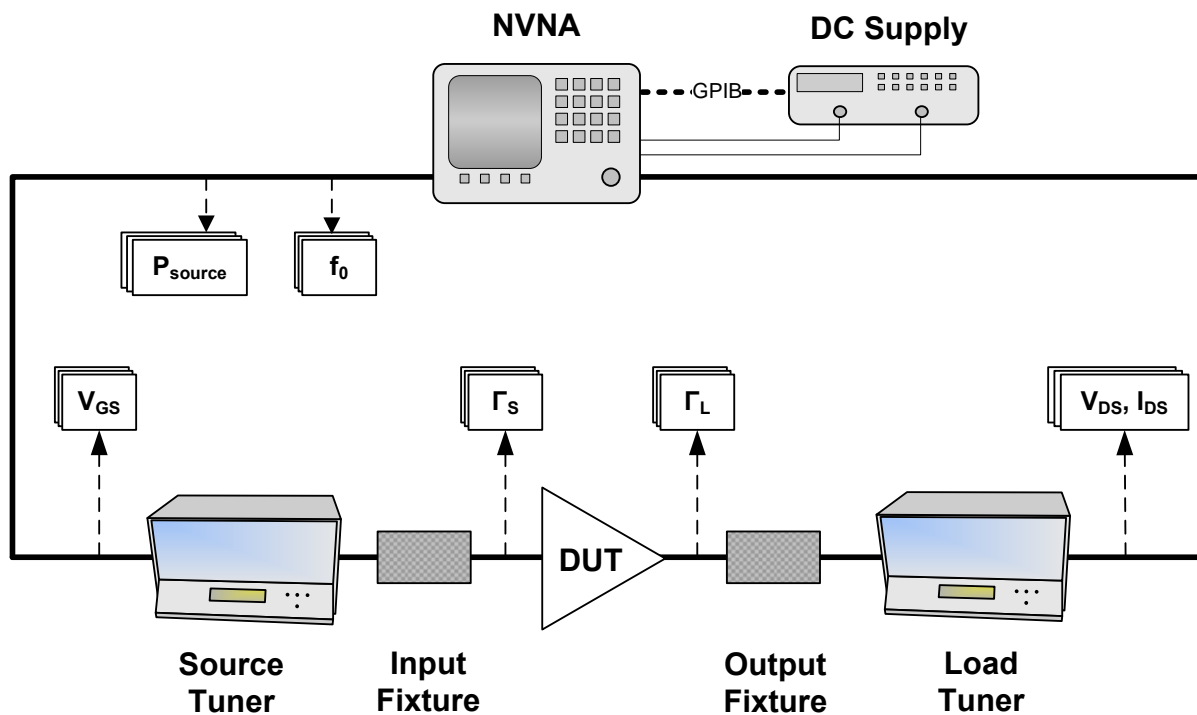

Fig. 1 Block diagram of X-parameter Load-Pull Setup

Agilent NVNA firmware is handling frequency and power sweeps and sweep variables controlled by GPIB instrument. Focus Microwaves' Load Pull Explorer (LPEx) software enables to integrate source and load tuners with the NVNA setup to perform source and load impedance sweeps. Focus software uses Agilent NVNA Application Programming Interface

(API) to synchronize tuner movement and NVNA measurements. The resulting load pull X-parameter file can then be used in Agilent ADS software. Fig. 2 show how the tuners work with the NVNA to get the X-parameters and how the measured X-parameters are used in ADS.
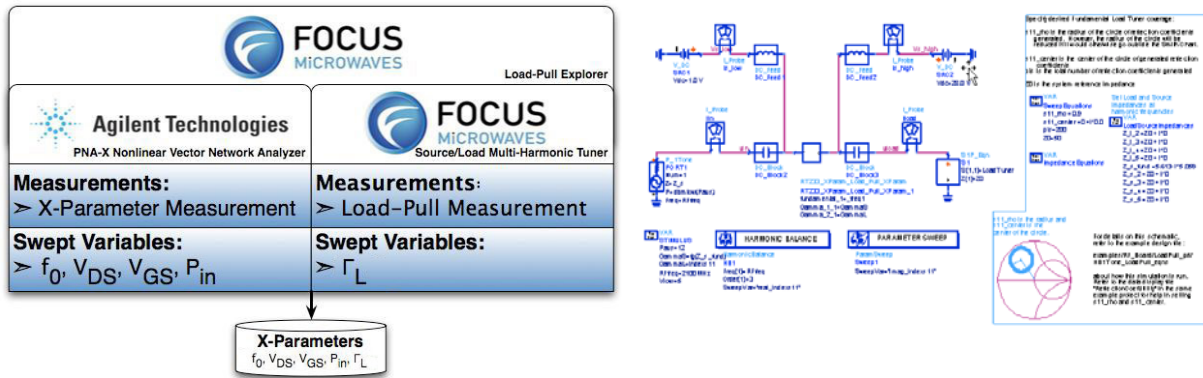

(a) X-Parameter Load-Pull Measurement   (b) ADS Load-Pull Simulation

Fig. 2 X-Parameter Measurement and ADS Simulation

The ADS simulated load pull results using load pull X-Parameter file are compared with traditional load pull measurement based on a RFHIC GaN power transistor @2.1 GHz. Fig. 3 shows the comparison results of drain efficiency, power added efficiency and output power contours. Load pull measured contours (blue) were measured using a traditional load pull setup includes signal generator, power meter and DC supply. Simulated contours (red) were made using load pull X-parameter file extracted by NVNA; this measurement used a setup similar to Fig. 1. It can be seen that the simulated and measured results are well matched especially at optimum Gamma.
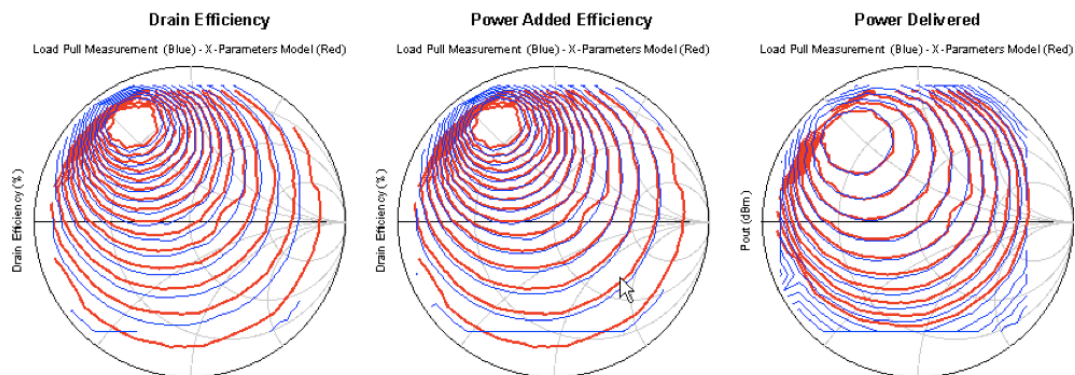
Fig. 3 Load-Pull vs. X-Parameter Comparison
(Red – Simulated   Blue - Measured)