Creating Measurement-Based Amplifier Behavioral Models

Connected Solutions
Application Bulletin 1476-1

ADS

PNA

**Off-the-shelf
component or existing
hardware**

Amplifier hardware

Agilent Technologies

Introduction

Characterizing an amplifier over frequency and power to create a behavioral model suitable for use in a circuit or system simulation can be a tedious, time-consuming task. The Power Swept S-Parameter application in the Advanced Design System (ADS) Connection Manager automates and simplifies this task.

Concept

A single set of S-parameters describes the behavior of a circuit at a specific power level. Multiple sets of S-parameters measured at different power levels are combined to create an amplifier behavioral model in ADS. The resulting behavioral model is used in simulations to determine characteristics such as gain compression or phase distortion versus input power. The model also is used to simulate the amplifier's modulated performance using modulated signal formats such as WCDMA, WLAN, EDGE, or 1XEVDO.

Several amplifier behavioral models are available in ADS. Refer to Table 1 for a listing of the major differences among these models.

Amplifier Model	Main Features
AmplifierP2D	Models all four S-parameters, including the fundamental, and the narrowband around the fundamental. Noise parameters can be added.
AmpSingle-Carrier	Models forward transmission. Linear interpolation of data.
AmplifierS2D	Models forward transmission, odd order harmonics. Polynomial curve fit of data.
GainRF	Models forward transmission. Data-based and parameter-based Ptolemy model. Linear interpolation of data.

Table 1. ADS provides several data-based amplifier behavioral models for circuit and system simulations.

This Application Bulletin uses the most comprehensive, AmplifierP2D model as an example.

Equipment Configuration

ADS 2003A and the optional Connection Manager are required for access to the Power Swept S-Parameter measurement panel.

A network analyzer is used to measure the amplifier. In this example, the E8358A Performance Network Analyzer (PNA) is used. An 82357A USB to GPIB Converter is used to connect the PNA to the PC running ADS 2003A. The amplifier to be characterized is an Agilent MGA-8A, 1.95-GHz amplifier.

Taking Data and Creating the Behavioral Model

1. The PNA first must be calibrated over the amplifier's operating frequency range of 1.935 GHz to 1.965 GHz. Once calibration is complete, follow these steps:

2. Open the Connection Manager Power Swept S-Parameter dialog box, shown in Figure 1, and select the PNA from the Select Instrument drop-down menu.

3. Enter the input power range over which the amplifier will be swept in the "Select Power Settings" portion of the dialog.

   In this example, a power range is selected which will drive the amplifier into compression.

4. Measure all four S-parameters, because the AmplifierP2D model is capable of modeling all four.

5. Select the AmplifierP2D model from the drop-down menu and enter a file name and a dataset name to save this model.

6. Click the "measure" button.

The Connection Manager steps the PNA through the power range selected, accumulates the S-parameters at each power level, and then converts this data to the AmplifierP2D behavioral model format. The model is then available for use in a simulation.

Figure 1. The Power Swept S-Parameter measurement panel of the ADS Connection Manager provides a single interface for entering all the necessary parameters.

Verifying CW Performance of the Amplifier Behavioral Model

Using the AmplifierP2D schematic component and referencing it to the file created by the Connection Manager, a harmonic balance simulation is performed to determine the CW performance of this behavioral model. The results of this simulation are shown in Figure 2. The results demonstrate that the amplifier behavioral model yields the gain compression and phase distortion that is expected of this amplifier.

Figure 2. The amplifier's gain compression and phase distortion are modeled, and the results of swept input versus output power are shown.

Measured Versus Modeled under Modulated Conditions

To validate that this behavioral model accurately predicts the amplifier's performance under modulated conditions, the amplifier's ACLR versus swept input power is measured. Then the ACLR is simulated using a WCDMA input signal. As shown in Figure 3, the simulated results match the measured results. Figure 3 also shows the simulation results from creating the AmplifierS2D, GainRF, and AmpSingleCarrier behavioral models. For this S21 example, all four models provide similar results.

WCDMA ACLR Comparison - 6 MHz Freq. Offset

Figure 3. Simulated versus modeled ACLR results using a WCDMA stimulus.

Summary

From linear, S-parameter measurements using ADS, a PNA, and the Power Swept S-Parameter application in the Connection Manager, it is possible to create a behavioral model of an amplifier capable of simulating the amplifier's behavior under modulated conditions. This behavioral model can be used in circuit and system simulations to verify performance of the amplifier within a circuit or system.

Required Equipment/Software

E8358A Performance Network Analyzer or; 8753/8722/8720/8719 Family of Network Analyzers

E5720A/AN Connection Manager

E8900A Design Environment

E8901A Data Display

E8823A Ptolemy Simulator

E8854A RF System Model Library

E8882A Harmonic Balance Simulator or E8853A RF System Simulator.

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