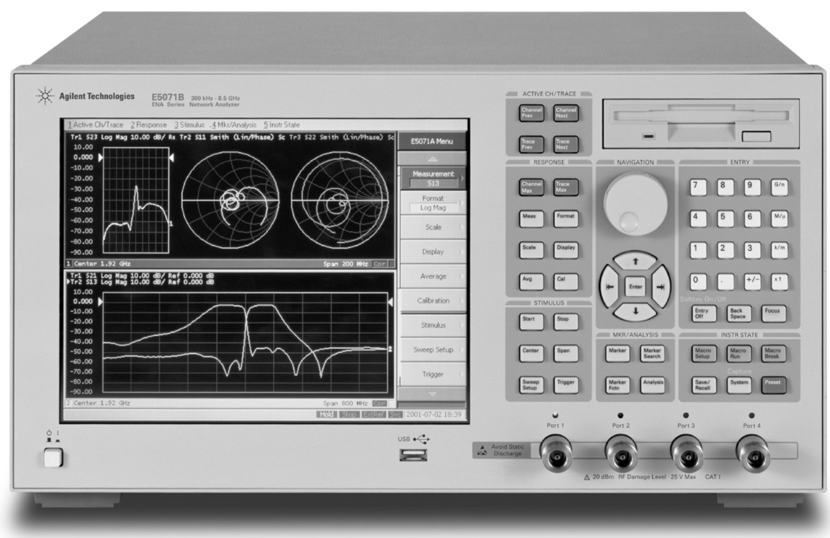
Agilent E5070B/E5071B
ENA Series RF Network Analyzers

Application Note 1463

Characterizing Differential Amplifiers with True Differential Signals



- True differential measurement method using hybrid junctions
- Mathematical balun extracts differential, common, and mode conversion S-parameters

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The Challenge of Today's Differential Amplifier Evaluation

One of the toughest challenges for RF amplifier manufacturers today is evaluating differential amplifiers. Since differential-mode signals and common-mode noise mix in real world circuits, differential amplifiers need to be carefully designed to work properly under real operating conditions. Thus, balun transformers, with a traditional 2-port network analyzer, have been used to convert single-ended signals to differential signals for practical evaluation. However, it is not possible to obtain accurate mode-conversion data and characteristics with this balun measurement method.

Differential amplifier measurement issues

Recently mixed-mode S-parameters based on single-ended measurements are becoming more common to characterize differential components. This method is valid for characterizing differential amplifiers when the amplifiers behave in the linear operating region. However, in this case differential amplifiers are not driven by true differential signals. To characterize differential amplifiers, even in the non-linear operating regions, it is necessary to drive them with true differential signals and to use 4-port network analyzers with some key measurement functions.

True differential measurement method using hybrid junctions

Differential amplifiers can be fully characterized using hybrid junctions with the Agilent E5070B/71B ENA Series 4-port network analyzers. As shown in Figure 1, a differential amplifier is driven by a true differential signal for the measurement. The characteristics of hybrid junctions need to be compensated to get the actual amplifier's response. The ENA Series network analyzers provide this compensation using the 4-port de-embedding function. The ENA also provides the measurement results converted from S-parameters to mixed-mode S-parameters using the fixture simulator function. In this way, the true differential characteristics of differential amplifiers can be measured.

The step-by-step procedure using the 4-port ENA and hybrid junction is as follows:

Step 1: Calibrate the ENA at the ends of cables as the calibration plane.

Step 2: Characterize a hybrid junction using a 4-port ENA. Additional cables/transmission lines can be modeled by using an ENA's port extension function. Measured S-parameters can be saved in touchstone format for de-embedding.

Step 3: Measure the differential amplifier using the measurement setup shown in Figure 1. Thus, the DUT can be driven by differential signals. The ENA's 4-port de-embedding function removes the effect of the hybrid junction.

Step 4: Obtain differential, common, and mode conversion S-parameters from the measurement result in Step 3. The ENA's mathematical balun will interpret them.

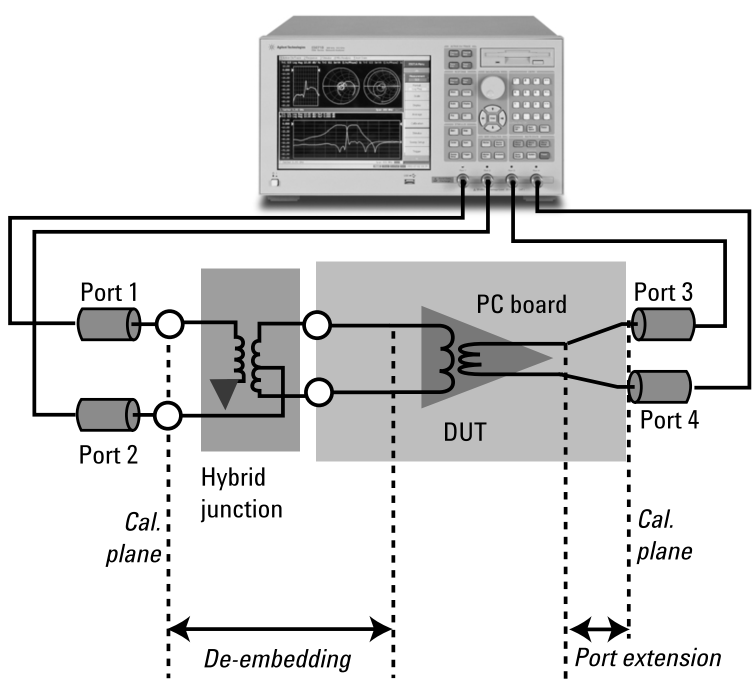

Figure 1. True differential measurement method using hybrid junctions

Measurement examples

Figure 2 shows the actual measurement results for gain compression using the true differential measurement method with a hybrid junction and the direct mixed-mode S-parameter measurement method (refer to Figure 3 for measurement setup). Comparing the two measurement results, non-linear characteristics of the DUT, such as Sdc11 and Sdc21 (common mode to differential mode conversion), can be measured with the true differential method. In this example, note that the measured differential gain such as Sdd21 are quite similar between two methods, since differential gain is the most important parameter of amplifiers.

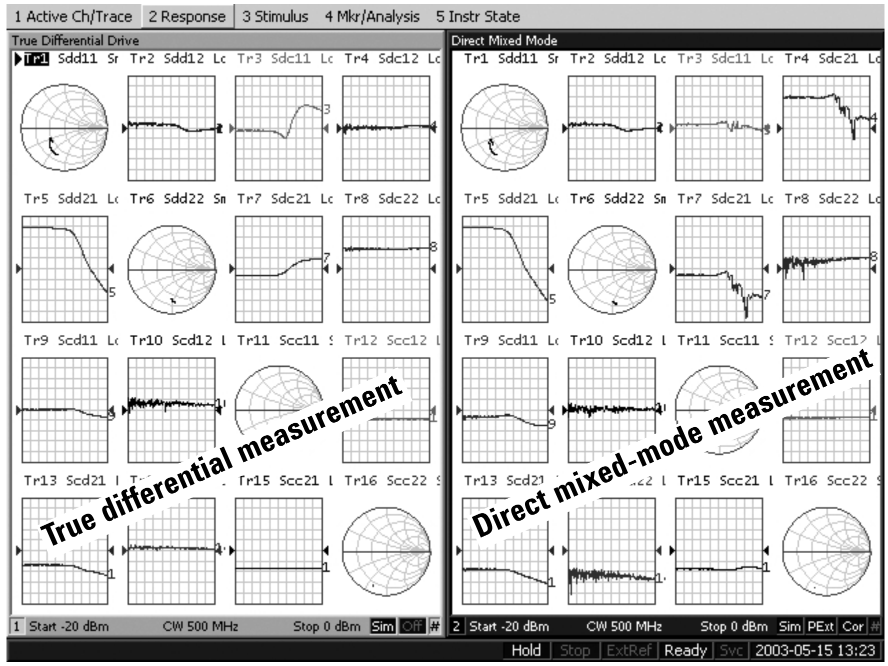

Figure 2. Differential amplifier measurement results

The ENA Series meets your measurement needs

There are many trade-offs with differential amplifier measurement methods as shown in Table 1 below. The ENA Series RF network analyzer with its high-performance, flexible measurement functions, and true differential characterization, is a valuable tool suited to meet your measurement needs.

For more information, please contact your local Agilent representative.

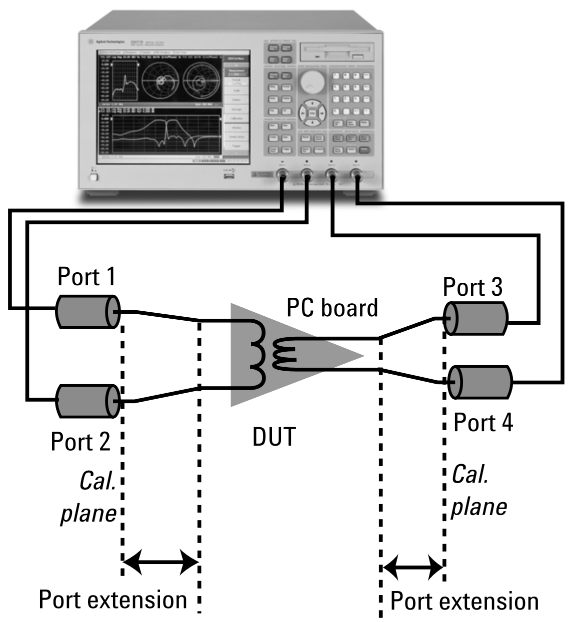

Figure 3. Direct mixed-mode S-parameter measurement method

	Advantages	Disadvantages
True differential measurement method using hybrid junctions	• Provides both differential-mode and common-mode signals for full characterization of differential amplifiers	• May be difficult to find the performance or broadband hybrid junctions • Requires characterization of hybrid junctions
Direct mixed-mode S-parameter measurement method	• Simple measurement procedure • Provides valid measurement results in the linear operating region	• May NOT provide accurate measurement results in non-linear operating region

Table 1. Measurement method comparison

Web Resources

For more information about Agilent ENA series network analyzers visit:

www.agilent.com/find/ena

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