Q & A

CASCADE MICROTECH

Innovating Test Technologies®

On-wafer Differential/Multiport Characterization Solution

Why is Cascade Microtech introducing this offering?

This Differential/Multiport test system solution offering is the latest in a series of recent and ongoing efforts by Cascade Microtech to provide complete, integrated test solutions to the RF wafer characterization and modeling market. These offerings demonstrate Cascade's continuing commitment to not only expanding the frontiers of technical RF test performance, but also to improve both the productivity of test engineers and the asset utilization of a company's investment in test equipment.

Why is a differential/multiport characterization solution important?

The use of differential circuit topologies is becoming increasingly common in a wide range of RF applications. Differential circuits have excellent immunity from many sources of noise such as that generated from power supplies, adjacent circuitry and other external sources that are coupled either electrically or electromagnetically. This inherent lower susceptibility is paving the way for new generations of cellular phones, high-speed digital equipment, and improved telecommunications tools with increased bandwidth.

Due to these performance advantages, circuits using differential and balanced components require less electromagnetic shielding, enabling the creation of smaller and lighter devices and also allowing the use of devices only requiring lower voltage differential signals that results in extending battery life.

What comprises this specific differential test solution offering?

This turnkey on-wafer solution includes dual high performance characterization probes, a differential ISS (calibration standard), an Agilent ENA Series RF network analyzer and Cascade's probing system. This approach facilitates the performance of the devices and circuits to be measured under their desired mode of operation, thereby reducing modeling and design cycle time.

This solution enables a differential-to-differential or single-ended-to-differential to be fully characterized.

As an integral part of this solution, Cascade has introduced the first-ever, dedicated dual and differential calibration standards for RF engineers who wish to characterize balanced devices using external baluns. Differential calibration standards have not been available until now.

In the past, the lack of differential calibration standards has meant that balanced devices and circuits could not be accurately characterized. Subsequently, it was very difficult for RF engineers to understand the performance of their devices and circuits under this desired mode of operation, resulting in multiple design cycles, higher yield loss, increased time and cost.

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How does this solution help RF semiconductor companies meet their strategic objectives?

At the highest level, implementation of a Differential test solution provides RF semiconductor companies with:

- Significantly improved characterization engineering productivity
- Reduced modeling and design cycle times
- Substantial time and cost savings
- The most advanced technical test capability available

Together, these capabilities are designed, and combined, to reduce a manufacturer's time-to-market for next generation chips.

What is the ENA?

The Agilent ENA Series network analyzers provide the comprehensive measurement capability required to test both multiport and balanced devices. The ENA Series offers 2 frequency coverages of 3 GHz (E5070B) or 8.5 GHz (E5071B) and 2-, 3-, or 4-test port options for simultaneous measurement of all signal paths in these multiport devices.

The ENA series delivers extensive analysis capabilities such as time domain transform with gating and mixed mode S-parameter measurements with matching circuit embedding/de-embedding and impedance conversion. In addition to the built-in Microsoft® Visual Basic for Applications (VBA) capability, the analyzer can be programmed via its COM or SCPI interface.

The ENA Series has a Windows®-based user interface and large 10.4-inch LCD. Built-in interfaces, such as GPIB, 10/100BaseT Ethernet, USB, VGA and parallel are also included.

How does Agilent Technologies' test station capability complement Cascade Microtech's test system offerings?

In addition to the benefits that have already been outlined, the ENA 4-port network analyzer is an integral part of a complete Cascade Microtech test system solution for on-wafer balanced device characterization. This complete solution includes high performance characterization dual probes, on-wafer dual and differential calibration standard substrates, RF probe stations plus turnkey installation, training and a single point of responsibility.

Having a complete test systems solution available nearly eliminates the amount of RF engineering time needed in the past to design, coordinate, locate, assemble and troubleshoot a test system compiled from various disparate equipment and component sources. Now, an engineering team can look to Cascade to handle those details and assure the solution is integrated and tested beforehand.

This offering allows an RF semiconductor company to use its RF engineering resources on product characterization and new product introduction – vis-à-vis test equipment and system design and construction – further improving company productivity and time-to-market.

What is a differential/balanced device?

In a balanced device, two terminals constitute a single port that will ideally only respond to or generate differential-mode signals. Differential signals are defined as two signals that are 180 degrees out of phase with one another. These devices do not respond to or generate in-phase signals, which are called common-mode signals.

Figure 1, shows a fully balanced amplifier, which has both differential inputs and outputs. The amplifier only responds to the difference between the input signals, and subsequently only produces an output signal based on that difference. One of the main reasons that balanced circuits are highly desirable is that undesirable interference signals from outside sources show up at both terminals of the device simultaneously, and are therefore rejected by the device.

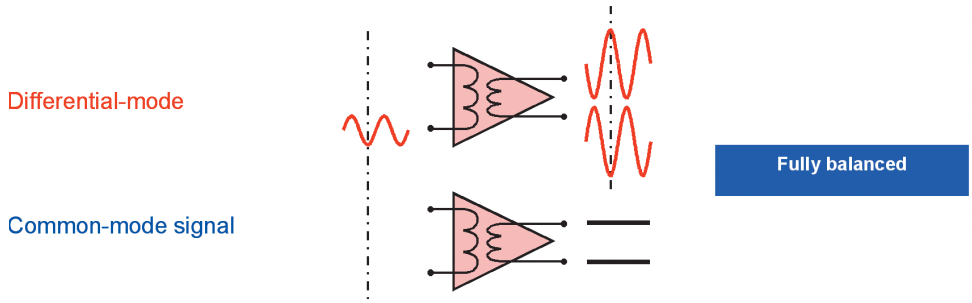


Figure 1

Nothing is perfect, therefore, balanced devices do produce a small amount of output from these stray interference input signals. This common mode signal is the result of differential to common mode conversion, and it is a source of electromagnetic interference. Therefore, each balanced port can support both a common-mode and a differential-mode signal. In a balanced device, each balanced port will support both a common-mode and a differential-mode signal. Consequently, to fully characterize a balanced device, the RF engineer needs to characterize the differential to differential mode, which represents the desired mode of operation, as well as the undesired mode conversions. This performance is described using mixed-mode S-parameters.

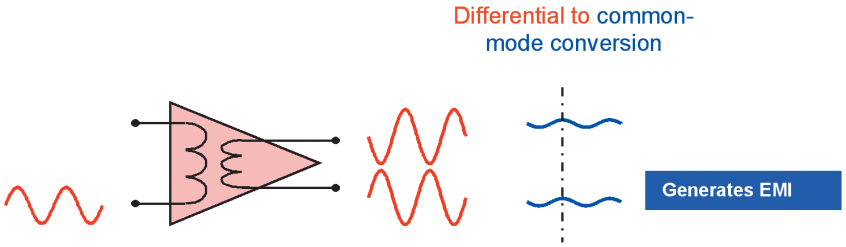


Figure 2

What is mode conversion?

Mode conversion is a device converting some of its incoming differential signal to common mode on its output, resulting in generated electro-magnetic interference (EMI). If a device converts some of its incoming common mode signal (typically noise) to differential signal at its output, it reduces the system's noise immunity.

How is a differential device measured using a network analyzer?

A single-ended network analyzer is used to measure a differential device. Each port of network analyzer is connected to each terminal of a differential device. Since a differential device has 2 terminals on each device port, a 4-port network analyzer is required to measure differential-to-differential device. The network analyzer measures regular S-parameters, then balanced parameters called mix-mode S-parameters are calculated mathematically. This measurement requires full 16 S-parameters for one single measurement of differential-to-differential devices, which means a fast network analyzer is required to have reasonable measurement speed.

What are mixed mode S-parameters?

Mixed-mode S-parameters enable us to understand a differential device's behavior including the performance in different conversion modes. In order to easily show mode conversion terms, "d" (differential-mode), "c" (common-mode) and "s" (single-mode) are attached together with S-parameters. For example, a mix-mode S-parameter "Sdc21" means characteristics from port 1 to port 2 and from common-mode to differential. When a differential-to-differential device is measured, there are 16 mix-mode S-parameters in total such as Sdd11 through Scc22. When a single-ended-to-differential device is measured, there are 9 mix-mode S-parameters. As mentioned earlier, these mix-mode S-parameters are obtained mathematically from regular S-parameters.

Why can't I simply use a two-port network analyzer to characterize my balanced device?

There are two problems with this approach. The first is that it is extremely time consuming. To fully characterize the device, an engineer must perform six two-port calibrations, and then measure all six paths. Ports that are not in the measurement path must be properly terminated. Without a four-port test set, this is a very tedious process.

This technique can also lead to misleading and inaccurate information. Without suitable analysis (taking the single-ended data and properly converting it to balanced or differential data), it is very difficult to understand actual performance of the balanced device. It is easy to reach the wrong conclusion when examining single-ended data of a balanced device. Also, critical differential design parameters such as the common-mode rejection ratio cannot be determined using just only two-port network analyzers.

What is the most common alternative that RF engineers have used to measure balanced devices?

Previously RF engineers have tried to use two baluns in conjunction with a standard two-port VNA. The baluns are used to convert from the single-ended signals from the VNA to differential signals. A typical measurement setup is shown in Figure 3.

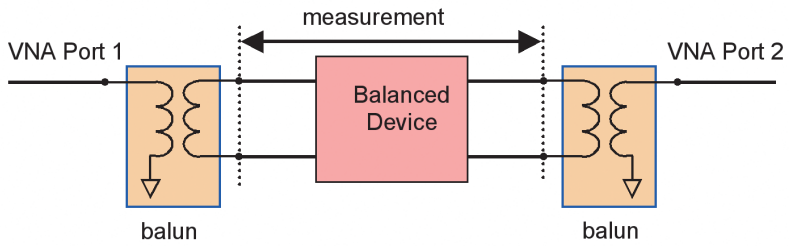


Figure 3

However, it has been impossible to actually perform on-wafer differential calibration using this approach due to the lack of truly differential calibration standards. Consequently, it has been very difficult for RF engineers to understand the performance of their devices and circuits under this desired mode of operation, resulting in multiple design cycles, higher yield loss, increased time and cost. A problem with this approach is that it results in an incomplete characterization of the device. When using baluns, only the four differential mode S-parameters are determined. Very important data required by the RF design engineers, relating to the mode conversions and the common-mode operation of the device is not determined. Another potential restriction of using a Balun is that they typically have a narrow bandwidth and subsequently do not have enough coverage of bandwidth for semiconductor device characterization. The introduction of the differential calibration substrate from Cascade Microtech means significant improvements in productivity and time-to-market for semiconductor manufacturers.

Why Cascade Microtech and Agilent Technologies?

Cascade Microtech is the world leader in on-wafer device characterization measurement solutions. Agilent Technologies is the world leader for providing test and measurement instrumentation to the semiconductor industry. Cascade Microtech is Agilent Technologies' largest Channel Partner. Agilent and Cascade have worked successfully for the past 20 years in providing leading edge technical solutions. Providing this solution brings a strongly differentiated offering that provides high value to the device engineering community.

Who is Cascade Microtech?

Cascade Microtech, Inc. is the worldwide leader in providing high frequency and parametric on-wafer test solutions. Engineers use our solutions to test and characterize integrated circuits (ICs) and photonic devices. These devices are then used in semiconductor applications, such as personal computers, servers, cell phones, consumer and automotive electronics, fiber-optics, PDAs, and other wireless products. Cascade Microtech also produces thin-film probe cards for production-level on-wafer testing of fine pitch, high-speed IC devices for broadband communications and networking, wireless and cell phones as well as other market applications. For more information visit www.cascademicrotech.com.

Who is Agilent Technologies?

Agilent Technologies Inc. (NYSE: A) is a global technology leader in communications, electronics and life sciences. The company's 37,000 employees serve customers in more than 120 countries. Agilent had net revenue of $8.4 billion in fiscal year 2001. Information about Agilent is available on the Web at www.agilent.com.

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