Test Adapter Substrates Ease The Task of Measuring PHEMT FETs

Figure 1 - ProbePoint™1003 Adapter Substrate

Summary

A new method of fixturing microstrip die and other non-coplanar devices is described. An example Pseudomorphic High Electron Mobility Transistor (FET) measurement to 50 GHz is shown along with companion noise parameters to 26 GHz. The direct adapter substrate calibration technique is discussed and verification data shown.

Introduction and Background

The use of coplanar and coaxial microprobes has made many microwave measurements easier and more accurate. However, there are many products, including FETs, MMICs, chip capacitors, chip resistors, chip inductors that are designed for microstrip applications. None of these products have the required signal and ground pads orientation and the required spacing allowing microprobing. These devices will generally be wire bonded into a circuit, so that the wire bond becomes one of the circuit elements. Consequently, it is desired that the measured S-parameters of this device also include the bond wire response. For example, a low noise GaAs FET die will generally be die attached to a metalized ceramic substrate, and the gate, drain, and source are bond wired (using very short double bonds) to the specified pads on the substrate. Note that the bond wire lengths of the test samples must be identical with the specific application.

Until recently, these measurements have been difficult and tedious. A new set of adapters and associated calibration technique makes these measurements straightforward. The adapters, shown in Figure 1, adapt a coplanar probe to microstrip, which connects to the DUT with bondwires. A typical low noise FET application is shown in Figure 2.

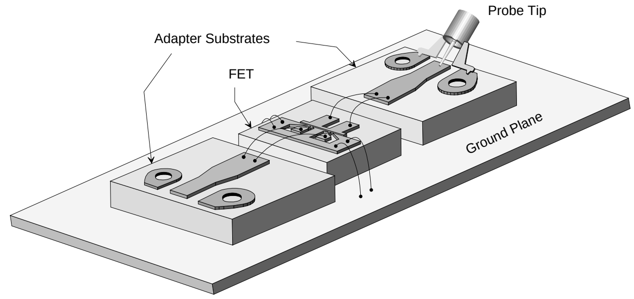


Figure 2. - PHEMT with Adapter Substrate

Double bonds (as used in the actual application) connect the gate and drain metalization to the adapter microstrip. The source metalization is wire bonded to the ground plane, which is common to the entire setup. Any gold metalized conductor works well for the carrier. The DUT dice and the adapter substrates are either attached with silver epoxy or eutectic solder, as required.

Example Measurements

Microwave semiconductor manufacturers and customers are using the adapters to measure advanced devices. An example use of the adapters is for recent measurements of the low noise Litton Solid State LP7512 PHEMT FETs S-Parameters to 50 GHz, and noise parameter measurements to 26 GHz. The DUTs were set up as shown above in Figure 2. using 10 mil thick adapter substrates. After calibration (described below), excellent data was obtained through 50 GHz. The S-parameter data is shown in Figure 3.

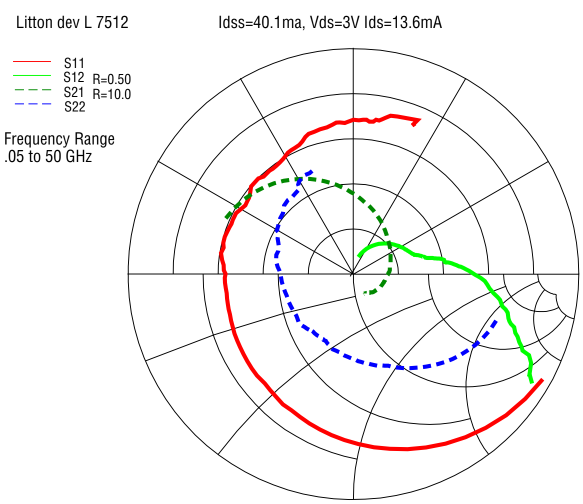


Figure 3. - LP7512 S-Parameters

The measured noise parameter data also looked equally as good and self consistent, particularly for such low noise devices. The quality of the data indicates that both the adapter substrates and the associated calibration techniques were performing properly, comparable to good “on-wafer” data. Important to the quality of the measurements is both the “transition” integrity from the microprobe tip to microstrip bond pad and the calibration precision.

Calibration

The calibration technique and standards are critical to the correct use of these adapters, particularly above 26 GHz. At lower frequencies, and for less demanding measurements, many people simply calibrate their Automatic Network Analyzer up to the probe tips, as before for on-wafer measurements. Then they move the reference planes out 5.1 ps to compensate for the adapter substrate delay. For more accurate requirements, and beyond 26 GHz, a better method is needed. This is provided by using a TRL calibration technique with the PP CM10 cal substrate. When used together with the cal kit available on floppy disk, the correct direct calibration of the adapter substrates is easily obtained. This technique was used in the above example.

Table 1. PP CM10 - Cal - Kit Description.

Cal Kit File Name	Cal Kit Name	Cal Method	Recommended Min/Max Frequency
CK_SOLT	PP10SOLT	Short, Open, Load, Thru	DC to 10 GHz
CK_LRM	PP10LRM	Line, Reflect, Match	DC to 50 GHz
CK_TRL	PP10TRL	Thru, Reflect, Line	1.5 to 50 GHz

The calibration technique is easy:

1. Load the TRL cal kit labeled CK_TRL into the network analyzer; see Table 1. If your Automatic Network Analyzer is not able to read the enclosed disk, a tabular listings for manual data input is available from J microTechnology.

2. Sequentially probe the standards standard identified in Figure 4, stepping through the cal process. It is important to place the probes at the same location with respect to the vias, when probing each calibration structure.

3. Verify the calibration. A one port verification can easily be performed by placing the probes, one at a time, on Line42S (see Figure 4). The response should be a spiral on a Smith chart, similar to Figure 5.

A two port cal can be verified by placing both probes on Line11 (a total 22.2 ps long line). Be sure to place the probes at the same position relative to the vias as during the cal process. The S11 and S22 response should be well controlled, with the maximum reflection of 30+ dB at 10 GHz, and 20-30 dB at 50 GHz. The delay should be 12 ps (read off the display of the Network Analyzer), demonstrating that the offset calibration is indeed offset by 5.1 ps on each port.

4. Proceed to measure

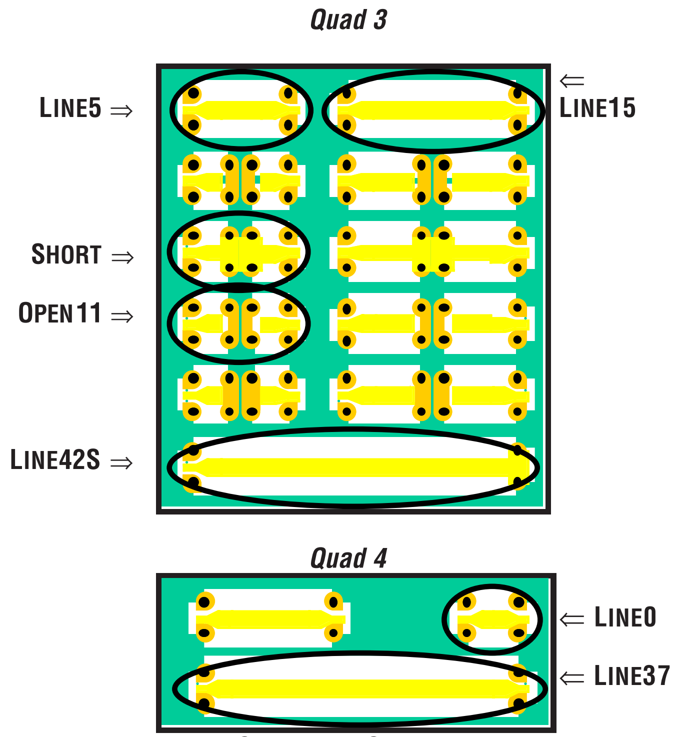
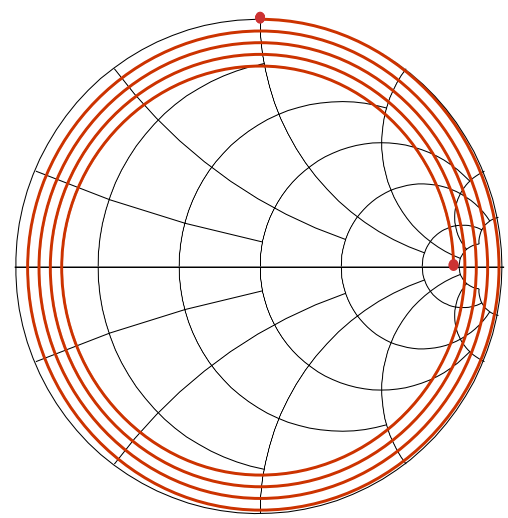


Figure 4 - TRL Calibration Structures on the ProbePoint™ CM10 Calibration Structures Substrate



50 MHz - 50 GHz

S11 - Line42S Calibration Verification

Figure 5. - Calibration Verification

Closing Discussion

In actual practice, it is relatively easy to get good calibrations to 50 GHz using the TRL methods, much easier than SOLT methods, for example. It is important though to consistently contact each calibration standard at the same position relative to the vias. This same relative position should be used also when performing measurements using the adapters substrates. Physical repeatibility is key to achieve electrical repeatibility.

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