Surface Mount Microwave Package Characterization Technique

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Abstract

We present a plastic package characterization technique using coplanar waveguide to package adapters (CPA) and line-reflect-match (LRM) [1,2] calibrations. LRM calibrations on off-set CPA standards are employed to de-embed the response of CPA adapters in measured S-parameters. A variety of small shrink outline packages (SSOP) has been characterized to 26.5 GHz using this technique.

Introduction

One solution for low cost microwave packaging is the use of surface mountable plastic packages to house MMICs so that the total assembly cost can be reduced. As a result, the need to develop characterization techniques for plastic packages has been motivated in order to predict the parasitic behavior of packages at microwave frequencies. However, conventional characterization approaches face two major difficulties: (1) obtaining resonant-free S-parameters in the GHz regime, and (2) extracting interconnects from measured data.

In this paper, we present an on-wafer method to characterize SSOP plastic packages to 26.5 GHz. An electrical model for an 16-pin SSOP package is developed to 26.5 GHz. An amplifier is assembled in a package and tested to verify the validity of the electrical model. In addition, package isolation is studied experimentally using this technique.

Design and Approaches

In order to obtain resonant-free S-parameters of a package under test, a variety of thin-film alumina substrates as shown in Figure 1 has been designed to mount SSOP packages. The package was mounted on the substrate using conductive epoxy. The substrate established RF interconnections from coplanar waveguide microprobes to packages via CPA adapters. CPA calibration standards, Figure 2, for LRM calibrations were fabricated including a thru, an offset short, an offset open, a 50-ohm offset load, and a delay line. The use of custom calibration standards allowed the measurement reference planes to be shifted from probe tips to package pins.

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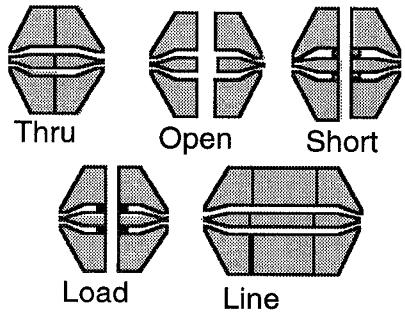

Figure 2. Custom CPA Calibration Standards

Figure 3 shows the schematic set-up of a package under test. In the package, a coplanar waveguide transmission line is placed on a ground plate. The grounds of the CPW are wirebonded to the pins which are mounted to the grounds of CPA adapters. In addition, the grounds of the CPW are connected to the ground plate using wirebonds. The signal line of the CPW is wirebonded to the signal pins. This package is mounted with a thru standard. Plastic is molded to form a SSOP plastic package.

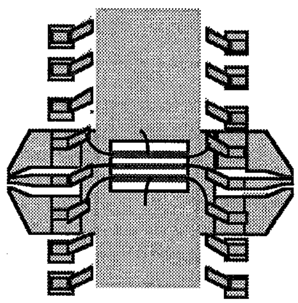

Figure 3. Schematic of Measurement Set-up

Experimental Results

LRM calibrations were performed on the CPA standards using an 8510C Network Analyzer and air coplanar microprobes. After calibrations, measurement reference planes were defined at CPA interfaces where the package pins were mounted. Therefore, the responses of adapters were not included in measured S-parameters. Measured S-parameters of a thru package under test were obtained to 26.5 Ghz.

Figure 4 shows the electrical model of the package. In the equivalent circuit model of the package, transmission lines are used as distributed models for the wirebonds. The transmission lines TL_s and TL-g1 modeled the wirebond from the signal pins to the signal lines of the CPW and the wirebonds from ground pins to the grounds of the CPW respectively. The transmission line TL_g2 was employed to characterize the wirebond connecting the grounds of the CPW to the ground plate. The inductors and capacitors correspond to the inductance of the package pins and the capacitance from the pins to ground respectively. The values of the circuit elements are determined by optimizing the circuit until the modeled and measured S-parameters are well correlated. The values of the components are shown in tables 1 and 2. Figures 5 and 6 demonstrate excellent correlation between measured and modeled S-parameters of the package under test.

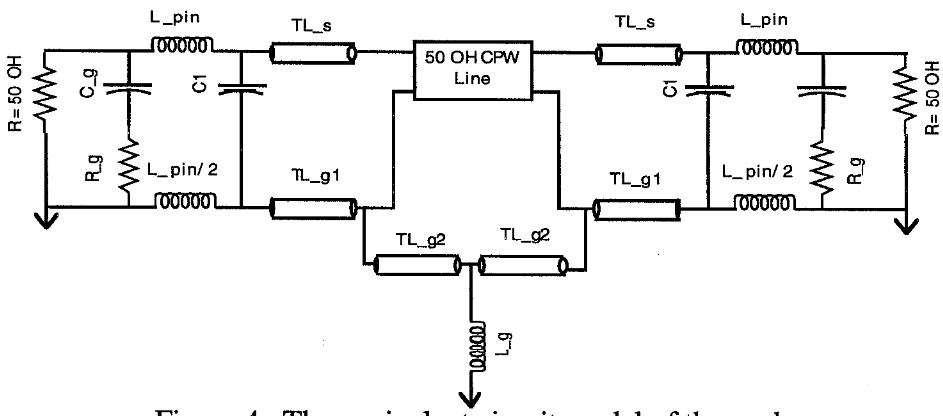

Figure 4. The equivalent circuit model of the package

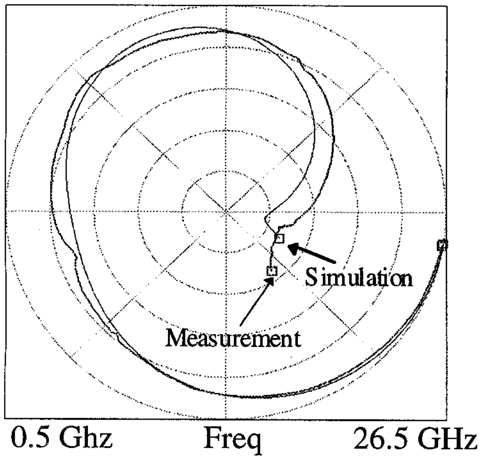

Figure 5. Measued and modeled S21 of the thru package

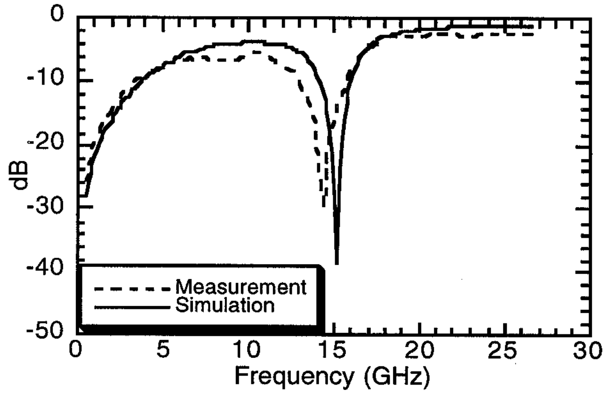

Figure 6. Measured and modeled S11 of the thru package

Transmission Lines

Trans. Lines	Z_o (OH)	l (mil)	R (OH/mm)
LS_s	82.0	74.5	0.001
TL_g1	41.0	74.5	0.0005
TL_g2	41.0	46.5	0.0005

Table 1.

Lumped Elements

L_pin (nH)	L_g (nH)	C_g (pF)	C1 (pF)	R_g (OH)
0.85	0.022	0.22	0.044	3.7

Table 2.

An amplifier has been used as a test vehicle to demonstrate the usefulness of the electrical model of SSOP packages. The amplifier was simulated using MDS with the electrical model the SSOP package added to the amplifier circuit. Simulated S-parameters were used to model the packaged amplifier. The amplifier was then assembled in the package and measured using CPA adapters. Figure 7 demonstrated excellent correlation between experimental and simulation results of the amplifier in the package.

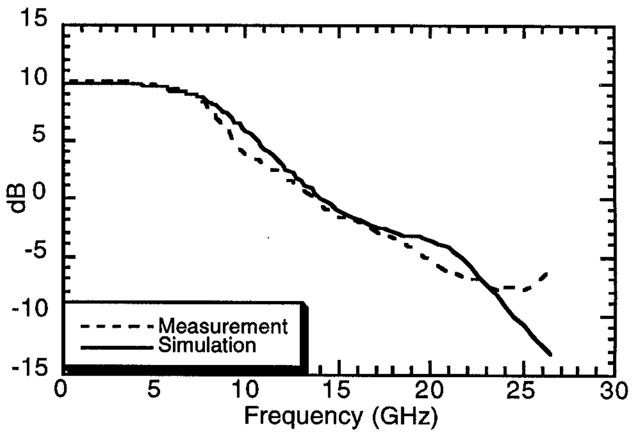

Figure 7. Measured and modeled S21 of the amplifier in the package

Using the above technique, we can correctly model the impact of the package prior to assembly. Furthermore, the electrical model of the SSOP can be incorporated into the design of an amplifier so that impedance matching can be achieved. Package and interconnect parasitics can be accounted in the design of the MMICs. In doing so, the design process can be expedited.

In addition, the isolation of a 16 pin shrink small outline package, SSOP, was measured with the technique presented in this paper. On-wafer CPW 50 Ohm loads were placed in the arrangements shown in Figure 8. The loads were mounted onto the ground backside of the package with conductive epoxy and the pads of the load were wirebonded to the lead frame of the package. One configuration placed the two loads in opposite corners of the package with the signal fed from opposite sides of the package. Because of the difficulty in measuring the weak signals associated with isolation, the source power was increased to 12 dBm to make the S21 measurement on the network analyzer. The measured isolation of the package is shown in Figure 9.

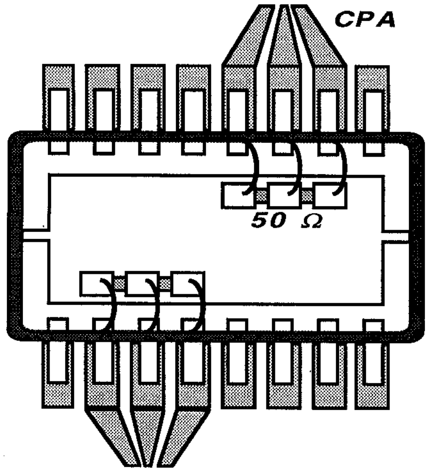

Figure 8. Package set-up for isolation measurement

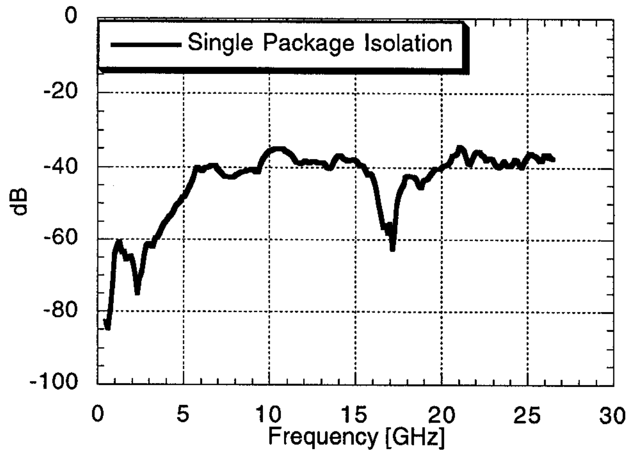

Figure 9. Isolation measurement of a SSOP package

Conclusion

A new technique for on-wafer measurement of surface mountable packages has been developed. This technique can be generalized to characterize surface mount packages to 26.5 GHz. By using offset CPA calibration standards and calibrating to the ends of the package leads, only the response of the package were gathered, and resonant free measurements of the high frequency electrical performance of plastic packages have been demonstrated by characterizing the isolation of a plastic package. A DC-26.5 GHz model of the package has been generated from measured data and validated with an experimental results measured from an amplifier test vehicle.

Acknowledgments

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Reference

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