Table 1 Inductive Iris cavity resonant frequencies (GHz)

Δl	**1 mm**	**1/3 mm**	**1/5 mm**
TLM	31.732	31.062	30.922
Marcuvitz	30.560	-	-
Static Correction	30.889	-	-

Table 2 Capacitive Iris Cavity Resonant Frequencies (GHz)

Δl	**1 mm**	**1/3 mm**	**1/5 mm**	**1/11 mm**
TLM	11.175	11.935	12.105	12.260
Marcuvitz	12.475	-	-	-
Static Correction	12.510		-	-

Conclusion

A novel systematic procedure to incorporate static field configuration into a 3D-TLM mesh has been proposed. The method introduces the correct field singularity by exploiting the previous incident and reflected link-line voltages surrounding the corner node. The procedure requires negligible additional operations and leads to a saving in computational time and memory of two orders of magnitude.

Further details can be found in:

G. Tardioli, L. Cascio, and W. J. R. Hoefer, “Special 3D-TLM Corner Nodes for Singular Field Regions”, in 1997 IEEE MTT Symposium Dig., pp. 317-320, Denver, Colorado, June 9-13, 1997.

3) Characterization of Surface Mount Package Effects with the TLM Method

(Giampaolo Tardioli, Mario Righi, Lucia Cascio, and Wolfgang J. R. Hoefer)

Introduction

A typical problem facing designers of integrated circuits is to determine the effect of the package on the performance of a monolythic microwave integrated circuit (MMIC) it contains. The presence of leads, bond wires and grounding pins affects the MMIC behavior. These effects must be included in the early design stages. In order to avoid costly design cycles, an electromagnetic approach becomes attractive to predict accurately the performances of a packaged circuit.

We have performed the full wave time-domain analysis of a surface mount plastic package containing a simplified MMIC (a thru connection and a microstrip spiral inductor). Problems such as poor grounding terminations and crosstalk with neighboring lines are also considered as they can occur at relatively low frequencies.

Finally, we propose an approach to isolate the package effects. The whole structure is segmented and the package is characterized by its scattering parameters. In this way the package needs only to be modeled once for a given configuration. The package effects are extracted and combined with the MMIC parameters to predict the performance of the packaged circuit at a fraction of the computational costs. In addition, the MMIC circuit can be optimized by including the package effects from the design stages, thus significantly reducing costly cut-and-try cycles.

TLM Analysis of the SOIC-8 Package

The described critical issues appear in the analysis of the SOIC-8 surface mount package. The structure comprises 8 leads which allow the IC to be soldered onto the mother-board. Some of the leads are extended to the paddle to provide grounding to the MMIC, while other leads are connected by bond wires to the MMIC providing input and output to the circuit. The geometry of the structure is shown in Fig. 5.

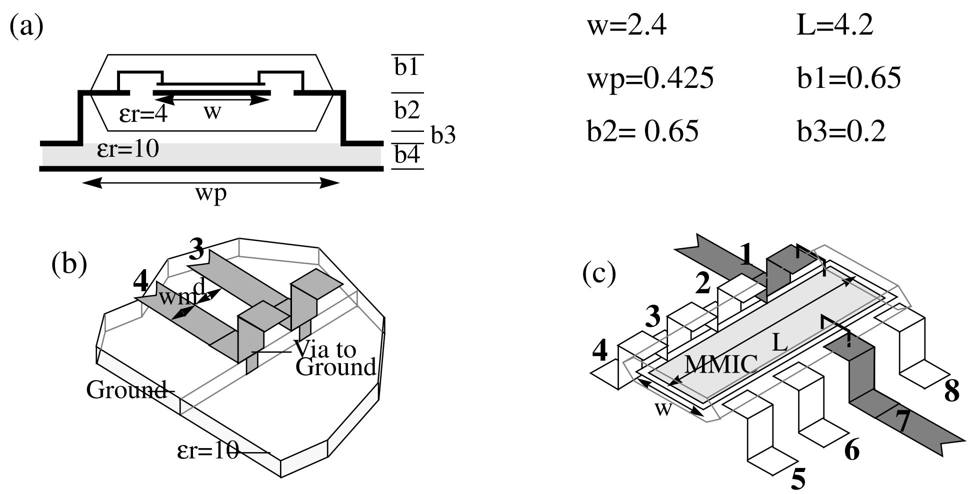

Fig. 5 Plastic Package dimensions and geometrical details. All dimensions are in mm. (a) Package section (b) Detail of the grounding to the mother-board (c) MMIC mounted on the plastic package

Poor Grounding

In order to highlight the effects of the grounding leads, a microstrip spiral inductor has been analyzed under poor grounding characteristics (Fig. 6a). In this case the configuration was: leads 1 and 5 provide input and output to the spiral; all other leads are grounded on the mother-board by means of vias, but only leads 4 and 8 are extended to provide ground on the package. Poor ground was simulated by assuming a faulty solder connection on one of the vias so that either via no. 4 or via no. 8 is ineffective.

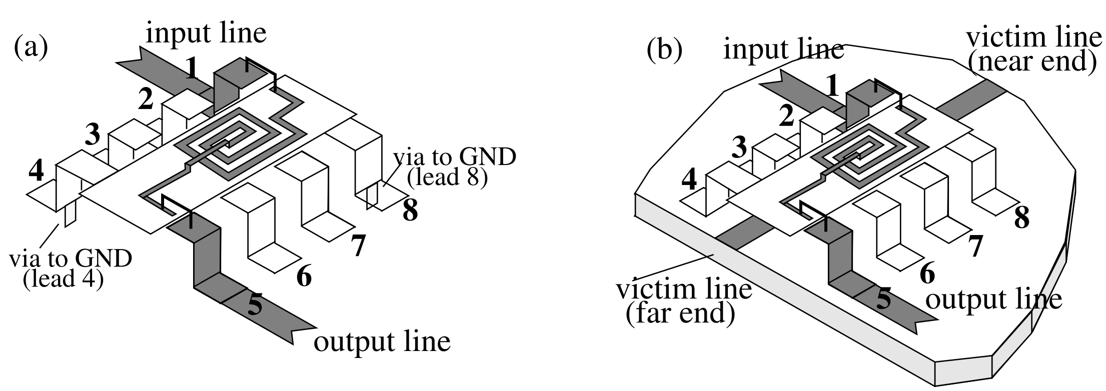

Fig. 6 (a) Geometry of the microstrip spiral inductor under poor grounding conditions (either via on lead 4 or 8 are made ineffective. (b) Geometry of the package with a microstrip line beneath it to evaluate crosstalk.

Results are shown in Fig. 7. The results for the two cases of ineffective vias are overlapping and only one of the two is shown. This similarity can be explained considering the high degree of symmetry of the structure. Note that a poor ground reduces the bandwidth of operation of the inductor by 500 MHz because of the additional inductance provided by the longer path of the return currents.

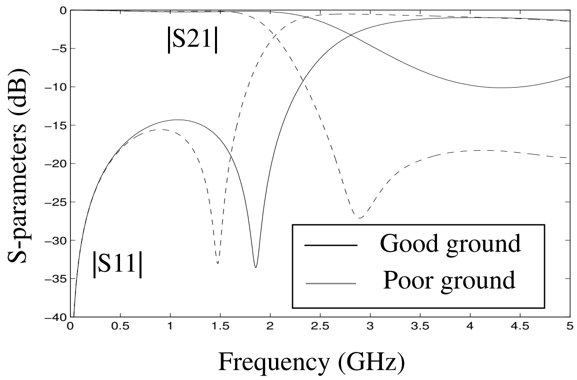

Fig. 7 Scattering parameters for the microstrip spiral inductor on the MMIC under good and poor grounding conditions

Crosstalk

The same microstrip inductor has been used to evaluate the presence of crosstalk between the input line and a crossing microstrip on the mother-board (Fig. 6b). A transient analysis of the problem has been performed and the time domain waveforms coupled to the victim crossing line have been extracted. The The voltage transmission coefficients to the victim line are shown in Fig. 8. Note that an unexpected amount of power is coupled on the near end. In the frequency range from 7 to 9 GHz as much as 13% of the voltage is transferred to the victim line.

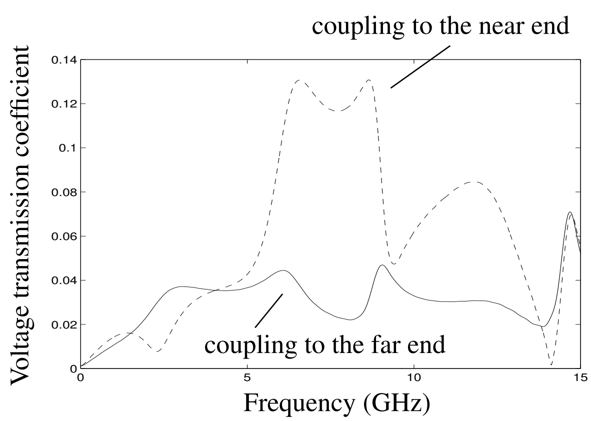

Fig. 8 Voltage transmission coefficient from the input line to the victim line for the configuration in Fig. 6b.

Segmentation

In order to isolate the package effect, we have segmented the structure into 3 sections. A first section consisting of the microstrip on the mother-board, the transition to the package, the bonding wire and the initial section of the MMIC. A second section composed of the MMIC itself; in this case a thru connection and a microstrip spiral inductor. A third section, similar to the first, to provide transition to the output line on the mother-board. The process is illustrated in Fig. 9, where the dashed lines represent the reference planes at which the segmentation was operated.

The scattering parameters of the segmented structure and of the full structure for the two cases are shown in Fig. 10. From these results it appears that the proposed approach is reliable in the frequency range dc to ~4 GHz. Above this frequency, the assumption of single mode interaction between the different sections fails to accurately describe the overall behavior of the circuit thus requiring a more sophisticated multi-port approach.

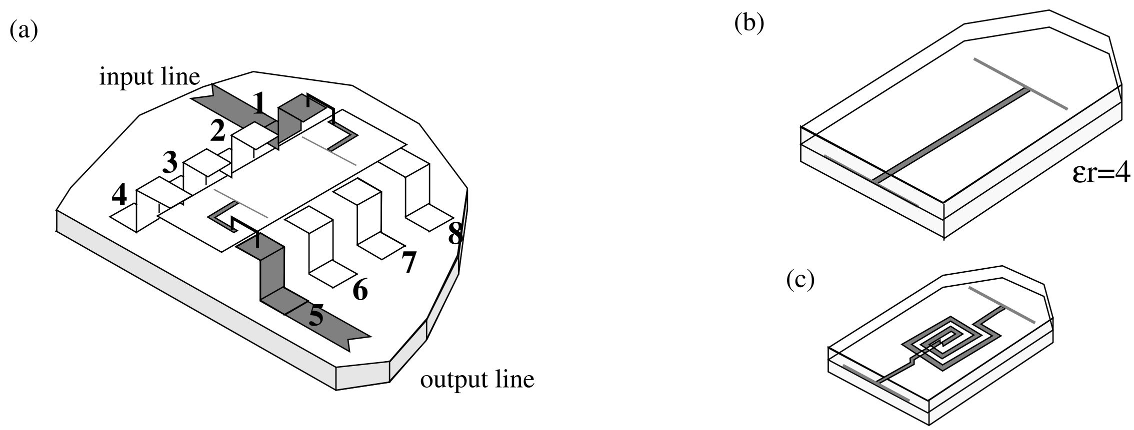

Fig. 9 Segmented structure: (a) input and output sections, (b) embedded thru connection, (c) embedded spiral inductor. The dashed lines represent the reference planes.

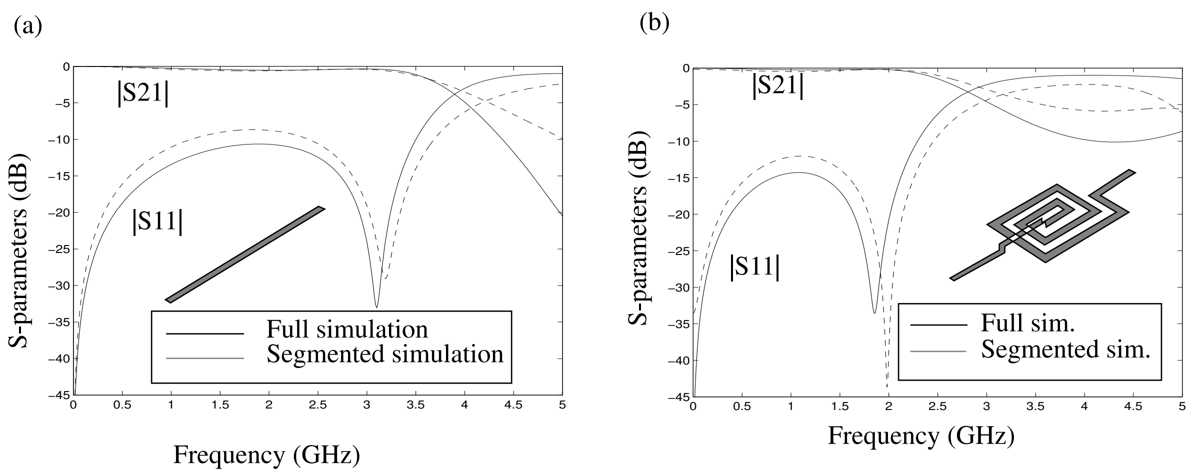

Fig. 10 Scattering parameters of the segmented structure compared with those of a full simulation; (a) thru connection, (b) spiral inductor.

Conclusion

The full wave analysis of a surface mount plastic package containing a test MMIC has been presented. The need for a full wave tool to characterize the package effect is highlighted, and valuable insight into the behavior of the packaged MMIC is gained. Poor grounding conditions have shown to change significantly the performance of the circuit, and crosstalk with crossing lines cannot be neglected.

A segmentation approach has also been proposed. The package effects have been extracted and combined with MMIC parameters to predict the performance of the packaged circuit at a fraction of the computational costs. In addition, the MMIC circuit can be optimized by including the package effects from the design stages.

Further details can be found in:

M. Righi, G. Tardioli, L. Cascio, W. J. R. Hoefer, “Time Domain Characterization of Packaging Effects via Segmentation Technique“ to be published on the Special Issue on Packaging Effects and Interconnects of the MTT-S IEEE Transactions, September 1997.

4) Modal Boundary Conditions for Waveguides of Arbitrary Cross-section with SCN TLM

(Jonathan Herring, Mario Righi, Wolfgang J. R. Hoefer)

Modal absorbing boundary conditions have been applied to a graded mesh using the hybrid node, and to homogeneous waveguides of arbitrary cross-section. The best performance is obtained with rectangular waveguides but examples show that the method can also be used for other geometries. A T-junction circular-to-sidecoupled rectangular waveguide example is given.

For rectangular waveguides, the modal field distribution is well known. In the application of modal boundary conditions to TLM, it is convenient to work directly with the voltage pulses, rather than with the total tangential field components. This is possible because the link-line voltages are a linear combination of the electric and magnetic fields. For a graded mesh using the hybrid node, three different impedances are assigned to the three sets of link-lines contributing to each component of the magnetic field. The modal Green’s function is determined by the timestep and the node dimension perpendicular to the boundary; it is independent of the mesh grading in the cross-section.

Typical Green’s functions for the dominant mode in a WR28 waveguide are shown in the frequency domain in fig. 1, for the cases of (*i*) cubic nodes with the maximum timestep, (*ii*) cubic nodes with half the maximum timestep, and (*iii*) cuboid nodes of twice the length in the perpendicular direction and with the maximum timestep.

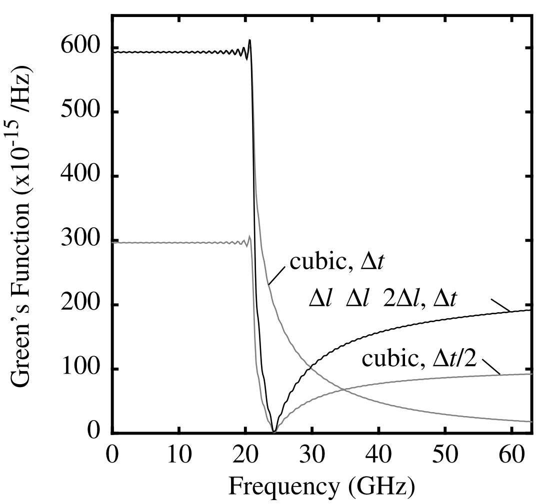

Fig. 1 – Modal Green’s functions for hybrid node

As the frequency increases, the curves tend towards the link-line reflection coefficient needed to match the TLM mesh to free-space: