Physical Model Order Reduction

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Abstract

This paper presents a novel approach for model order reduction for multilayer lossy RF embedded passives.

1 Introduction

As the Radiofrequency modules having been designed more compact than ever before, the parasitic effects due to the tightly coupled inter-connections on the circuit layout are inevitable. Therefore, an efficient method that

lent circuits from an electromagnetic model. Classic PEEC solver converts the layout into lumped RLC interconnection networks, including mutual couplings. Once a circuit model is generated, any circuit solver, such as SPICE, can manage the rest of the job. Unfortunately, the numbers of nodes and elements in the circuits are excessive. Therefore, researchers have been searching for an effective measure that can reduce the model order for accelerating the analysis of the circuit model.

Although exploited Krylov subspace methods and provided ways to speed up the simulation; they all lack the physical insight. In fact, matching the first two or three moments of the system via Taylor's expansion. Thus, these methods can not provide a clear physical explanation to the reduced circuit either. It is worth mentioning that has showed some insight for dealing with coupled inductances, even though the complexity of the scheme itself might have already limited its practical use.

The work presented in this paper is an extension to, in which a derived physically realizable lossless expressive circuit model reduction method is introduced. In this paper, a lossy model is the major concern. The passivity of the resultant circuit model by the new reduction scheme is guaranteed.

2 Theory

The circuit model generated by traditional quasi-static PEEC model for a multi-layer circuit layout with very thin conducting strips can easily incorporate the conducting loss, which is a major origin of the circuit loss.

and then superimpose this pre-calculated loss model to the generated circuit model to represent the conductor loss of the circuit. Therefore reasonable and time-saving approaches to calculate the loss for different meshing geometries are investigated.

Since the conductor loss is generally determined by the skin depth effect at RF frequency, a coarse but rapid approximation to this type of loss is to find out the skin depth and other shape factors of the mesh. Then the equivalent surface impedance can be easily calculated by $R_L = l/2\delta S$, where l is the mesh length, along which the current flows, S is the area of the equivalent crossing section where the current goes through, δ is the skin depth:

$$\delta = \frac{1}{\sqrt{\pi f \mu \sigma}}, \tag{1}$$

in which f is the frequency, μ is the magnetic permeability, and σ is the conductivity of the metal. In addition to this, various other empirical formulas, such as those in could also be used to determine the conducting loss.

could be computed by $G_C = \sigma C/\varepsilon$, where G_C is the bypassing conductance, C is the capacitance, ε and σ are the dielectric constant and the conductivity of the substrate, respectively.

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