Scalable metamodelling of microwave and RF circuits using methods of moments S-parameter data

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1. Introduction

Different numerical techniques, the most popular of which are the method of moments, the finite element and the finite difference techniques, can be used to accurately model passive microwave and RF circuits. These numerical techniques require a significant amount of expertise and computer resources. On the other hand circuit simulators are very fast, and offer a lot of different analysis possibilities. However, the number of available analytical models is limited, and the accuracy is not always guaranteed up to RF or microwave frequencies.

Several techniques (e.g. lookup tables [1], curve fitting techniques [2] and neural networks [3]) have been poposed to build models for passive RF and microwave circuits based on EM simulations. An important drawback of most techniques is the lack of knowledge about the accuracy of the resulting models. In the past, we developed an automated tool for building parameterized circuit models of general passive microwave and RF components with user-defined accuracy [4]-[5]. The analytical models represent the scattering parameters (or transmission line parameters) as a multidimensional function of frequency and geometrical parameters. The models are based on full-wave EM simulations, and can easily be incorporated in circuit simulators. This brings EM-accuracy and generality in the circuit simulator, without sacrificing speed.

In this contribution, more details will be given on the fully automated model generation process and the capabilities of the method will be illustrated by several challinging examples. It will also be shown how the new models can easily be incorporated into the overall design flow.

II. Adaptive multinomial data representation and data selection

The scattering parameters *S (*or transmission line parameters *R*, *L*, *G* and *C*) are approximated by a weighted sum of multidimensional orthonormal polynomials. These multinomials only depend on the physical parameters of the model (e.g. width, lenght, angle, ..), while the weights of these multinomials only depend on the frequency. The weights are calculated by fitting on a set of data points. The number of multinomials is adaptively increased until the error between the model and actual circuit data is lower than a user-defined accuracy level in all the data points. The modeling process starts with an initial set of data points. New data points are added adaptively until the user-defined accuracy level is guaranteed. The process used to select data points and to build the model is known as reflective exploration [6]. In the presentation, more details will be given on this reflective exploration process.

III. Examples

Several examples will be used to illustrate the method and to show how the adaptive process works: a double patch antenna consisting of two semi-circular patches of different diameter and indirectly excited by a microstrip line; a butterfly capacitor and a microstrip fed patch antenna. In this last case e.g., the automated modeling tool was used to generate analytical circuit models for all sub-parts of the structure (transmission line, open end, slot coupler, step in width, corner-fed patch). These analytical models are then used to optimize the structure with respect to its resonance frequency. Comparison with direct EM-simulation of the complete structure, shows that a divide and conquer strategy based on analytical models for the different parts yields a considerable gain in overall optimisation time without loss of accuracy.

References

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