

Neural Modeling and Space Mapping: Two Approaches to Circuit Design

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Background

The drive in the microwave industry for manufacturability-driven design and time-to-market demands powerful and efficient computer-aided design tools. The need for statistical analysis and yield optimization coupled with the desire to use accurate physics-based and EM-based models leads to tasks that are computationally intensive using conventional approaches. We present two recent advances in the microwave CAD area, Artificial Neural Network (ANN) based modeling and Space Mapping (SM) based modeling for fast and accurate design of microwave components and circuits.

Artificial Neural Network (ANN) Based Device Modeling

ANNs are biologically inspired computational models capable of learning and generalization. They are a powerful vehicle for modeling high-dimensional and highly nonlinear devices. The size of an ANN model does not grow exponentially with dimension and, in theory, can approximate any degree of nonlinearity to any desired level of accuracy, provided a deterministic relationship between input and target exists. Its computational speed is very high, making it very suitable for highly iterative processes such as microwave circuit yield optimization and statistical design. The most widely used ANN paradigm in the microwave arena is the multi-layer perceptron (MLP). Advanced techniques utilizing electrical/microwave knowledge in developing neural network models will be presented [1].

The Space Mapping Technique

The Space Mapping technique combines the computational efficiency of coarse models with the accuracy of fine models. The coarse models are typically empirical functions or equivalent circuits, which are computationally very efficient but have a limited validity range for their parameters. Fine models can be provided by an electromagnetic (EM) simulator, or even by direct measurements: they are very accurate but CPU intensive. The SM technique establishes a mathematical link between the coarse and the fine models, and directs the bulk of CPU intensive evaluations to the coarse model, while preserving the accuracy of the fine model.

Novel Contributions

We will highlight a recent breakthrough in the CAD area which combines SM and ANN technologies [2]. Three novel techniques have been proposed to generate SM based neuromodels: Space-Mapped Neuromodeling (SMN), Frequency-Dependent Space-Mapped Neuromodeling (FDSMN), and Frequency Space-Mapped Neuromodeling (FSMN).

References

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- [2] J.W. Bandler, M.A. Ismail, J.E. Rayas-Sánchez and Q.J. Zhang, "Neuromodeling of microwave circuits exploiting space mapping technology," *IEEE MTT-S Int. Microwave Symp.* (Anaheim, CA), 1999.