Efficient Implementation of Different Integral Equation Formulations for the analysis of 3D Rectangular Waveguide Microwave Circuits

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Extended Abstract

The popularization of the use of waveguide devices has led to the emergence of different numerical techniques to analyze these devices. In this contribution, different integral equation formulations [1] will be used, where the boundary conditions on the waveguide walls are modeled by Green's functions incorporated to their kernel. Due to this, an important advantage of this type of formulation is that a complete mesh of the analyzed structure is not needed, which greatly reduces the number of unknowns to be solved. In this work, we propose a comparison of the numerical performance of three different integral equation implementations such as the electric field integral equation (EFIE), magnetic field integral (MFIE) and combined field integral equation (CFIE) formulations, applied to rectangular waveguide problems including arbitrarily shaped conducting objects. The kernels of these IE formulations are written in terms of the Lorenz gauge rectangular waveguide Green's functions. All of these integral equations will be solved by the Method of Moments (MoM) [2], using a combination of subsectional rooftop and/or Rao-Wilton-Glisson (RWG) basis and test functions (Galerkin approach), defined respectively on rectangular and triangular mesh elements. Unfortunately, the efficiency of the different integral equation techniques proposed is limited by the slow convergence associated to the computation of the rectangular waveguide Green's functions. In our numerical implementation, this drawback has effectively been avoided by using series acceleration techniques such as Ewald method, both in the Green's functions of the rectangular waveguide [3] and in their corresponding derivatives [4]. The importance of evaluating the derivatives of the Green's functions in an efficient way, as explained in [4], is due to the appearance of this kind of contribution in the formulation and numerical implementation of the MFIE and CFIE. This evaluation provides a new alternative for evaluating the response of microwave circuits in waveguide technology. Finally, we have checked the accuracy and efficiency of these integral equation formulations by comparing the results obtained with simulations performed using commercial full-wave software suites such as ANSYS HFSS [5]. This comparison allows us to study the numerical performance of each of the proposed techniques, since they present some internal resonances at certain frequencies, causing an inaccurate numerical result. These resonances occur at different frequencies in each technique, so it is possible to assess which technique is the most appropriate according to the type of structure to be analyzed.

References

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