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Parametric Analysis of Lumped Devices Modeling Using Finite-Difference Time-Domain

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Abstract : The SPICE-based simulators are quite robust and widely used for simulation of electronic circuits, their algorithms support linear and non-linear lumped components and they can manipulate an expressive amount of encapsulated elements. Despite the great potential of these simulators based on SPICE in the analysis of quasi-static electromagnetic field interaction, that is, at low frequency, these simulators are limited when applied to microwave hybrid circuits in which there are both lumped and distributed elements. Usually the spatial discretization of the FDTD (Finite-Difference Time-Domain) method is done according to the actual size of the element under analysis. After spatial discretization, the Courant Stability Criterion calculates the maximum temporal discretization accepted for such spatial discretization and for the propagation velocity of the wave. This criterion guarantees the stability conditions for the leapfrogging of the Yee algorithm; however, it is known that for the field update, the stability of the complete FDTD procedure depends on factors other than just the stability of the Yee algorithm, because the FDTD program needs other algorithms in order to be useful in engineering problems. Examples of these algorithms are Absorbent Boundary Conditions (ABCs), excitation sources, subcellular techniques, grouped elements, and non-uniform or non-orthogonal meshes. In this work, the influence of the stability of the FDTD method in the modeling of concentrated elements such as resistive sources, resistors, capacitors, inductors and diode will be evaluated. In this paper is proposed, therefore, the electromagnetic modeling of electronic components in order to create models that satisfy the needs for simulations of circuits in ultra-wide frequencies. The models of the resistive source, the resistor, the capacitor, the inductor, and the diode will be evaluated, among the mathematical models for lumped components in the LE-FDTD method (Lumped-Element Finite-Difference Time-Domain), through the parametric analysis of Yee cells size which discretizes the lumped components. In this way, it is sought to find an ideal cell size so that the analysis in FDTD environment is in greater agreement with the expected circuit behavior, maintaining the stability conditions of this method. Based on the mathematical models and the theoretical basis of the required extensions of the FDTD method, the computational implementation of the models in Matlab® environment is carried out. The boundary condition Mur is used as the absorbing boundary of the FDTD method. The validation of the model is done through the comparison between the obtained results by the FDTD method through the electric field values and the currents in the components, and the analytical results using circuit parameters.

Keywords : hybrid circuits, LE-FDTD, lumped element, parametric analysis
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