Higher Order Time-Domain Finite Element Method for Microwave Device Modeling with Generalized Hexahedral Elements

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References:
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Abstract:
A novel higher order and large-domain Galerkin type finite element method (FEM) is proposed for direct 3-D electromagnetic modeling in the time domain (TD). The method is implemented in the TDFEM analysis of multiport microwave waveguide devices with arbitrary metallic and dielectric discontinuities. It is based on the geometrical modeling using Lagrange-type interpolation generalized hexahedra of arbitrary geometrical-mapping orders, field expansion in terms of hierarchical curl-conforming 3-D polynomial vector basis functions of arbitrarily high field-approximation orders, time stepping with an implicit unconditionally stable finite difference scheme invoking the Newmark-beta method, and mesh truncation introducing the waveguide port boundary condition. Numerical examples demonstrate excellent accuracy, efficiency, stability, convergence, and versatility of the presented method, and very effective large-domain TDFEM models of 3-D waveguide discontinuities using minimal numbers of large conformal finite elements and minimal numbers of unknowns. The results obtained by the higher order TDFEM are in an excellent agreement with indirect solutions obtained from the FEM analysis in the frequency domain in conjunction with the discrete Fourier transform and its inverse, as well as with measurements and with alternative full-wave numerical solutions in both time and frequency domains.

Keywords:
transient response, curved parametric elements, higher order modeling, Electromagnetic analysis, waveguide discontinuities, finite element methods (FEMs), microwave devices, time domain analysis, numerical techniques