A Discontinuous Spectral Element Time-Domain Method for Electromagnetic Devices

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Time-domain methods for electromagnetic devices can provide important transient and broadband frequency information. Recently, the discontinuous Galerkin method (DGM) has been studied owing to its high-order accuracy. The most important feature of this method is that it allows the numerical solution to be discontinuous across interfaces between elements. A set of local basis functions are employed for each elements rather than for the complete domain. Different types of element such as hexahedrons, prisms or tetrahedrons are allowed in modeling. This hybrid mesh is more flexible, and hence is expected to be more efficient than the single shaped mesh.

For practical problems, the physical domain is large and complex, and the solution is not smooth due to the presence of interfaces. In this paper, we present a discontinuous spectral element time-domain (SETD) method to solve the first-order formulation of Maxwell's equations. This method combines the SETD method with DGM to optimize the distribution of nodal points in a multiscale problem where different regions are best discretized by different order basis functions. Thus, the basis functions can be discontinuous across regions. With each element, the choice of nodal points and quadrature integration points are based on Gauss-Lobatto-Legendre (GLL) polynomials. Because the basis functions of the discontinuous SETD are orthogonal and because the GLL quadrature is used, the mass matrix is block-diagonal and thus we can avoid the inversion of a large mass matrix. The time integration is obtained by a fourth-order, five-stage low storgae Runge-Kutta scheme.

To verify the efficiency of the discontinuous SETD, we apply it to test models which include high permittivity regions as well as free space. The results are compared with those by the continuous SETD. Several numerical examples illustrate the usefulness of the proposed method.