A Time Domain Discontinuous Galerkin Surface Integral Equation Method for Electromagnetic Scattering Analysis of Nonpenetrable Objects

Xuezhe Tian* [1,2], Jin-Fa Lee [2], and Gaobiao Xiao[1]
(1) Key Laboratory of Ministry of Education of Design and Electromagnetic Compatibility of High-Speed Electronic Systems, Shanghai Jiao Tong University, Shanghai, 200240, China
(2) ElectroScience Lab, Ohio State University, Columbus, 43212, OH, USA

The discontinuous Galerkin surface integral (IEDG) method provides an appealing solution to the large-scale and multi-scale electromagnetic radiation and scattering problems. It employs the square integrable surface vector functions for both the trial and test function spaces, without considering the continuity across the element's boundaries. Based on the combined integral equation (CFIE), the Galerkin weak formulation can be established using particular surface and contour boundary penalty terms (Z. Peng, K.-H. Lim and J.-F. Lee, IEEE Trans. Antennas Propag., 61, 3617–3628, 2013). Various applications in challenging real-world objects composed of both nonpenetrable and piecewise homogeneous materials have demonstrated the flexibility and versatility of the IEDG method.

In this paper, a time domain discontinuous Galerkin surface integral (TD-IEDG) method is proposed. It not only inherits the merits of the frequency domain IEDG method, but also possesses the superiority of the time domain integral equations (TDIEs). Inspired by the IEDG method, a novel time domain version of the Galerkin weak formulation is introduced based on the time domain combined field integral equation (TD-CFIE). Solutions of the TD-IEDG can be obtained using the marching on in time (MOT) scheme. The TD-IEDG method provides excellent flexibility and capability when dealing with wideband, multi-scale and electrically large problems. The determination of interior penalty stabilization function in the TD-IEDG system is verified through series of numerical experiments. Robust stability property of the TD-IEDG is demonstrated though eigenvalue analysis using the companion matrix technique. Transient scattering analysis from nonpenetrable targets using both conformal and non-conformal meshes will be presented, justifying the stability, accuracy and capability of the proposed TD-IEDG method.