Time Stepping Alternatives for Higher Order Time-Domain Mixed Finite-Elements

Zane D. Crawford and B. Shanker
Michigan State University, East Lansing, MI 48824

The language of differential forms has been used for decades to create mixed finite-element methods (MFEM) in electromagnetics for both frequency domain and time domain analysis. Differential forms provides a different viewpoint with which to describe the behavior of various electromagnetic fields and sources (K. Warnick and P. Russer, Progress in Electromagnetics Research, 148,83-112,2014). One such example has been to use Whitney 1-forms for edge elements and Whitney 2-forms as face elements can be used to represent the electric field and magnetic flux density in a mixed finite element system (B. He and F. Teixeira, 17,5,313-315,2007). Other work has shown the use of Higher order edge and face elements for time domain analysis (R. Rieben, D. White, and G. Rodrigue, IEEE Transactions on Antennas and Propagation, 52, 8, 2190-2195, 2004). However, most literature only analyzes the MFEM system with leapfrog time-stepping, thus ignoring a host of different methods that could bring a different set of benefits that may be more appropriate for certain applications.

In this work , we examine alternative time-stepping schemes within the context of higher order that will hopefully enable larger time steps while providing greater accuracy as well as stability. Particularly, we will focus on multistep methods, namely second and fourth-order Newmark methods and predictor-corrector schemes. Current work that is presented at this conference shows that Newmark methods can be unconditionally stable for the lowest order coupled Maxwell MFEM system. In this paper, we seek to extend this to higher order spatial and temporal discretizations by deriving stability bounds and we will study convergence with respect to order in space, time, and refinement. Further, we will compare different methods with respect to these metrics. The proposed data will be presented at the conference.