Time-Stepping Schemes for Quasi-Magnetostatic Analysis of Magnetic-Conducting Materials

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Quasi-magnetostatic volume integral equations (VIE) discretized using the Locally-Corrected Nyström (LCN) formulation have been used (J. Young et al, IEEE Trans. Magnetics, 2, Art. ID 7000406, 2015) to analyze magnetic and/or conducting material excited by low-frequency, time-harmonic sources as well as slowly time-varying sources. For time-varying sources, backward Euler schemes usually provide good results, but, for magnetic-conducting materials, noise is sometimes observed in the resulting solutions if the magnetic material hysteresis curve has rapidly varying sections. For example, the TEAM Workshop Problem 10 (T. Nakata et al, COMPEL, 9, 181-190, 1990) was analyzed using a backward Euler scheme, and the magnetic flux density results are plotted versus time in Figure 1 for search coils 1 to 3. The results exhibit high-frequency noise overlaying the signal.

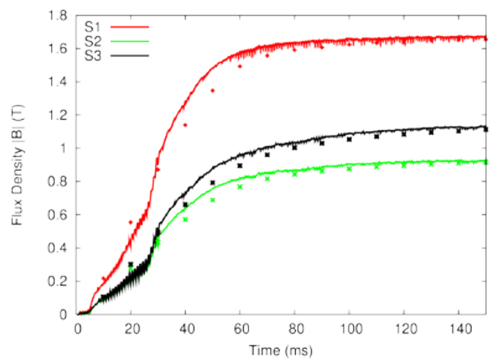

Figure 1. TEAM Workshop Problem 10 computed (solid lines) and measured (squares, from T. Nakata et al, COMPEL, 9, 181-190, 1990) flux densities for search coils 1 – 3 (S1, S2, S3, respectively)

In this paper, an alternative time-stepping scheme based on time integration in the context of quasi-magnetostatic analysis of magnetic-conducing materials is presented. The time integration scheme is expected to smooth out the noise while maintaining solution accuracy. The volume integral equation LCN discretization will be discussed as well as appropriate modifications to efficiently implement the time-integration scheme for application to very large problems. Results will be presented and contrasted with a backward Euler method.