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Advanced EM Modeling in Support of Buried Target Detection and Identification[1]

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The detection and discrimination of buried unexploded ordnance is essential for restoration of millions of acres of munitions testing grounds to public use. Public safety is paramount so high detection probability is essential, and accurate discrimination is key for economically feasible remediation. Time domain electromagnetic (TDEM) induction methods in principle have the capability to address these criteria. The transmitter loop current pulse generates a magnetic field in the target region. This changing applied field, especially as the pulse terminates, induces currents in the target, generating a scattered magnetic field. The decaying scattered field, following pulse termination, induces the measured voltage in the receiver loop. There are three different regimes that one may identify in the voltage time traces: early, intermediate, and late time. At very early time, immediately following pulse termination, the currents are confined to the immediate surface of the target. The initial diffusion of these currents into the target interior leads to a 1/2 power law decay for nonferrous targets, (3/2 for ferrous targets). At intermediate time, as the currents penetrate the deeper target interior, the power law crosses over to a multi-exponential decay, representing the simultaneous presence of a finite set of exponentially decaying modes. Finally, at late time only the single, slowest decaying mode survives. At intermediate- to late-time our mean field algorithm models the dynamics by computing as large a number as possible of the modes, and determining the excitation level of each. At early time, the power law arises from a superposition of an essentially infinite number of exponentials, and a complementary theory, based on the detailed dynamics of the initial very thin surface current sheet, has been developed instead. We pre-compute intrinsic properties of modes containing all discrimination information of targets, and use this for nearly real-time inversion of TDEM measurement for target properties and subsequent discrimination.

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