Rong, Qing-Yi, “Mixed Potential Integral Equations Method in 3-D Induction Modeling”

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The Mixed Potential Integral Equations (MPIE) method is widely used in electromagnetic computational applications. It can also be employed in 3-D induction logging modeling. The MPIE method combined with the dyadic Green’s function (DGF) representation for potentials is used to compute electromagnetic field distributions in a formation that consists of planar, uniaxial anisotropic, multilayered beds. A set of coupled surface integral equations for the equivalent currents J and M at the media interfaces has been derived. Solving these equations via the method of moments (MoM) yields the equivalent currents J and M, which in turn allow fields everywhere to be computed using either homogeneous or layered media potential Green’s functions as appropriate to the region. The near fields (fields at the receiver) are calculated using reciprocity once the equivalent surface currents are computed.

The media interface surfaces are approximated by a mesh of planar triangles. The traditional RWG [7] basis functions are implemented to fill the system matrices. Then the RWG basis functions are mapped to loop/star basis functions to better handle low frequency requirements in induction modeling.

The layered medium Green’s functions with mixed potential representations are also developed following the approach of Michalski and Mosig. The magnetic and electric potentials are expressed in terms of spectral domain Green’s functions in the form of Sommerfeld integrals.

The resulting MPIE code can be used to model dipping beds or deviated wells. Only the triangular meshes at media interfaces need to be changed for different logging environments. The MPIE code can compute the fields of penetrable objects of arbitrary shapes.