A $\boldsymbol{T} - \phi, \phi$ FORMULATION FOR AN EDDY CURRENT PROBLEM

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ABSTRACT. The objective of this work is the solution of a time-harmonic eddy current problem with prescribed sources on the boundary of the conducting domain. This problem has been extensively studied in the last years by using different formulations; see, for instance, Chapter 8 of [1]. In this work, we will focus on a formulation that splits the magnetic field into three terms: a vector potential $\boldsymbol{T}$, defined in the conducting domain, a scalar potential ϕ, supported in the whole domain, and a linear combination of source fields, only depending on the geometrical domain. This so-called $\boldsymbol{T} - \phi, \phi$ formulation is one of the most used in commercial software for solving three-dimensional eddy current problems (e.g., Cedrat Flux®, ANSYS Maxwell®).

To compute the source field functions we follow the idea proposed in [3], which consists in using the analytical expression of the Biot-Savart law in the dielectric domain. The most important advantage of this methodology, compared with other solutions found in the literature, is that it eliminates the use of multivalued scalar potentials, even in the case of non-simply connected dielectrics.

Concerning the discretization, "edge" finite elements will be employed for the approximation of both the source field and the vector potential, and standard Lagrange finite elements for the scalar potential.

We will establish an equivalence between the $\boldsymbol{T} - \phi, \phi$ formulation of the problem and a slight variation of the magnetic field formulation introduced in [2]. This equivalence, proved at both continuous and discrete levels, will be the key to obtain the well-posedness of the $\boldsymbol{T} - \phi, \phi$ formulation and the convergence results for the discrete scheme. Finally, we will present some numerical results that corroborate the analytical ones.

Keywords: Eddy current problems; Low-frequency harmonic Maxwell equations; Finite element approximation

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