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Cell Method and Modified Nodal Method in Eddy Current Electromagnetic Problems

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Abstract. This paper present an approximation of an electromagnetic eddy current problem in 2D coupled with circuital equations, using the Finite Formulation of Electromagnetics Fields and the modified nodal method. The definition equations of the two conductor models (filiform and solid types) are deducted with this formulation. The analysis is performed at steady state and transient state. To the transient state, a classical scheme of time discretization is used with the implicit Runge-Kutta method for two states. As validation method have been compared results between Finite Element Method and Finite Formulation of Electromagnetics Fields.

Key words

Finite Formulation, Modified Nodal Method, Transient State, Implicit Euler Method.

1. Introduction

There are several references that use the circuital equations using modified nodal method (MNM) and finite element method (FEM) [1], [2], [3].
In this paper is used a variation of the modified nodal method (MNM) and the finite formulation of electromagnetics fields (FFEF) applied to the Maxwell's equations. With this procedure is possible to assemble the continuous behavior of the discretized field equations, with the circuital equations in a single matrix.

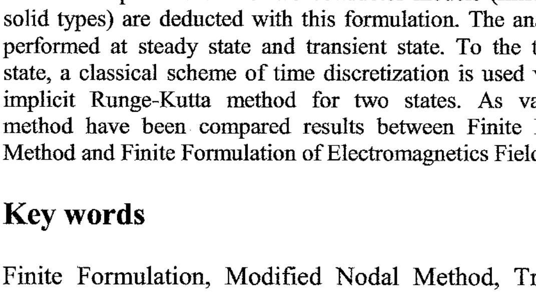

Fig. 1. Mixed-models representation.

The matrix equations are implemented with the Scilab, a scientific software package for numerical computations.

To the continuous domain discretization is used the Gmsh program, that is an automatic 3D finite element mesh generator, with pre- and post-processing facilities [4].
In this paper is developed a method that uses both tools, the MNM and FFEF. This allows the simultaneous analysis of the distributed and concentrated models as shown in Fig. 1.

2. Finite Formulation

The finite formulation of electromagnetics fields (FFEF) is based on the use of scalar global variables [5], obtained by integrating field variables on a double system of meshes, strictly connected by relations of duality.
Global variables are distinguished in two types, the configuration variables (CV) associated to the primal mesh and the source variables (SV), associated to the dual one. CV involved in the magnetostatic problems are magnetic fluxes φ on primal faces and line integral a of magnetic vector potential on primal edges. The considered SV are magnetomotive forces F on dual edges.
The proposed solution relies on the portioning of the magnetic domain in a dual system of barycentric hexahedral meshes but the same theoretical scheme can be applied to unstructured meshes [6]. The topological magnetostatic equations are expressed according to Tonti formulation [5].

3. Variation of the MNM

The fundamental idea is to modify the MNM introducing two new sets respect to this method, so that the elements are separated into five disjoint sets between them Fig. 2.
In a first group A_1, those elements that can be expressed as admittances are included. In a second group A_2, are included those elements that can not be represented as admittance or a current value is required. The third group A_3, the independent current sources are included. In a fourth group A_4, the so called 'solid conductor model' elements are modeled. At this set are includes the voltages