1928
K N Toosi University of Technology
Faculty of Electrical Engineering
Center of Excellence in Computation and Characterization of Devices and Subsystems

The Second Iranian Conference on Engineering Electromagnetics (ICEEM 2014), Jan. 8-9, 2014

Iranian Scientific Society of Engineering Electromagnetics

Time-Transient Nonlinear Modeling of Electromagnetic Systems Using Quadratic Finite Element Method

S. Asghari*, E. Fallah

Department of Electrical Engineering, University of Guilan, Rasht, Iran

***Corresponding author: s.asghari.g@gmail.com**

ABSTRACT— Behavior of ferromagnetic materials is considered as an important issue in magnetic studies. A prevalent method for modeling is finite element method (FEM). While modeling a material by FEM with linear elements, we might face with some problems like divergence of calculations, and discontinuity of flux density along two adjacent element. An alternative for overcoming this, is using quadratic elements.
A typical system is modeled by FEM with both linear and quadratic elements, and a comparison between them, shows better performance of quadratic elements over linear ones.

KEYWORDS: finite element method, linear elements, nonlinear modeling, quadratic elements, time-transient analysis.

I. INTRODUCTION

Accurate modeling of ferromagnetic materials is an important issue for designing electromagnetic systems. Among methods which are used for electromagnetic field problems, finite element method is more prevalent because of its easier implementation. Also, the most important advantage of FEM than other methods is its ability in modeling of intricate boundaries and obtaining more accurate results[1]. In usual FEM, in most studies like [2] and [3], linear elements were used for modeling of ferromagnetic materials, but when more accurate models are needed, it is proposed to use quadratic FEM [4].

In primary studies for modeling of ferromagnetic materials, a constant coefficient of permeability was used for this aim [5], but then some other methods like magnetic characteristic [6], and hysteresis models where used [2], [7]. In this studies which have been done by linear FEM, some problems was occurred like divergence of calculations, and discontinuity of flux density along two adjacent element. An alternative for overcoming this, is using quadratic elements which is used in this study.

In this study, the applied method for obtaining the flux density starts with a primary surmise, and then continues by solving algebraic linear equation system, by the method which has been proposed in [8] where stiffness matrix and input vector is updated in each iteration till the best answer obtained. Note that the stiffness matrix in FEM represents the resistance of the element to change when subjected to external influences which is thoroughly discussed in this paper.

In section II, quadratic FEM is introduced. Section III, discusses about modeling of ferromagnetic material. In section IV, a case