Engineering Analysis with Boundary Elements 35 (2011) 768–775

Contents lists available at ScienceDirect

Engineering Analysis with Boundary Elements

journal homepage: www.elsevier.com/locate/enganabound

Study of the monopolar RWG and monopolar $\boldsymbol{n}\times\boldsymbol{RWG}$ basis functions for electromagnetic scattering analysis

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ARTICLE INFO

Article history:
Received 11 March 2009
Accepted 9 December 2010
Available online 5 February 2011

Keywords:
Electromagnetic scattering
Magnetic field integral equation
Moment methods
Singularity extraction

ABSTRACT

In this paper, we study the accuracy and the efficiency of the monopolar divergence-conforming Rao–Wilton–Glisson (RWG) and the monopolar curl-conforming $\boldsymbol{n}\times\boldsymbol{RWG}$ basis functions for the magnetic field integral equation (MFIE). Similar to cases using RWG and $\boldsymbol{n}\times\boldsymbol{RWG}$ basis functions for the MFIE, there are two impedance matrix elements calculation schemes if the monopolar RWG and monopolar $\boldsymbol{n}\times\boldsymbol{RWG}$ basis functions are used to the MFIE, respectively. The monopolar basis functions and the implementation schemes used for the MFIE are discussed. The scattering cross section data as well as the CPU time needed to fill the corresponding impedance matrix obtained from numerical solutions of these implementation schemes using monopolar basis functions are investigated. For the monopolar basis functions and the implementation schemes considered, the first scheme of the MFIE using the monopolar curl-conforming $\boldsymbol{n}\times\boldsymbol{RWG}$ basis functions gives most accurate results and it is the best choice for the use of the monopolar basis functions to the MFIE.

1. Introduction

Method of Moments (MoM) [1] is an effective method for electromagnetic scattering analysis of three-dimensional (3-D) conducting objects. Both the electric field integral equation (EFIE) [2] and the magnetic field integral equation (MFIE) [2] are used widely to MoM with Galerkin's method for objects with closed surfaces. To solve these integral equations by MoM, we need to first model the surface of a scatterer and then define a set of basis functions to expand the surface currents. In this process, planar triangular patch models are particularly appropriate for modelling arbitrarily shaped surfaces. This is because planar triangular patches are capable of accurately conforming to any geometrical surface or boundary and a varying patch density can be obtained according to the resolution required in the surface geometry. At present, the Rao–Wilton–Glisson (RWG) [3] basis function defined on a pair of planar triangles sharing one common edge is used widely for the EFIE since this scheme gives accurate results for electromagnetic scattering analysis. In [4] the RWG basis functions are also used to the MFIE to expand the unknown induced currents. Unfortunately, triangulating the surfaces of conducting bodies and employing the RWG basis functions to expand the unknown induced currents for the MFIE often give less accurate results compared to the EFIE [5,6]. Several methods to improve the accuracy of the MFIE have been proposed such as the use of the solid-angle factor [6], the use of a more accurate MFIE implementation scheme for the RWG basis [7] and the use of new basis functions including the curl-conforming basis [8,9], the monopolar RWG and monopolar $\boldsymbol{n}\times\boldsymbol{RWG}$ set [10–12] and the Linear–Linear basis [13]. So far, there are two implementation schemes for the use of the RWG and the $\boldsymbol{n}\times\boldsymbol{RWG}$ basis functions to the MFIE which have already been studied in [4,7] and [8,9], respectively. The choice of the basis and testing functions to these schemes has also been discussed in [14]. It should be noted that the monopolar RWG and monopolar $\boldsymbol{n}\times\boldsymbol{RWG}$ functions adopt the definition of the RWG and $\boldsymbol{n}\times\boldsymbol{RWG}$ functions inside each triangle, respectively. The two MFIE implementation schemes for the RWG [4,7] and the $\boldsymbol{n}\times\boldsymbol{RWG}$ [8,9] basis functions are also suited to the corresponding monopolar part. Since the accuracy of the MFIE can be improved greatly by the use of a new MFIE implementation scheme for the RWG in [7] and by the use of two MFIE implementation schemes for the $\boldsymbol{n}\times\boldsymbol{RWG}$ basis functions in [8,9], respectively, then the accuracy study of the MFIE using the monoplar RWG and monopolar $\boldsymbol{n}\times\boldsymbol{RWG}$ basis functions, respectively, for these two schemes is also an important topic. This is because the use of the monopolar basis functions will double the number of unknowns compared to that of the corresponding dipolar basis functions [10] and we hope to improve the accuracy of the MFIE-RWG scheme most effectively by the use of more accurate monopolar basis functions. However, a detailed study of these two implementation schemes to these two kinds of monopolar basis functions is seldom reported.

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doi:10.1016/j.enganabound.2010.12.007