Analysis of Linear Antenna near Dielectric Object by CBFM

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***Abstract*—Dipole antenna in the vicinity of dielectric object is analyzed by characteristic basis function method (CBFM). Accuracy of numerical analysis is investigated by using different block division for the antenna and dielectric object. It is shown that all antenna segments should be allocated in the same block for calculating input reactance accurately. In addition, it is demonstrated that polarization current in the vicinity of the dipole antenna must be allocated in the block including antenna segments.**

I. Introduction

Method of Moments (MoM) is known as one of the famous techniques for analysis of antennas or scatterers [1]. In previous years, application of the MoM has been limited to simple and small problems such as electrically small linear antennas due to poor computer performance [2]. However, in recent years, the MoM has been applied to complicated problems including large conducting surfaces or dielectric objects since powerful computers with high performance CPU and large computer memories are available. Especially, numerical analysis of antenna in the vicinity of dielectric object is one of the attractive problems for the MoM [3]. For analysis of problems including dielectric objects, the MoM is applied to volume integral equation (VIE-MoM). However, the VIE-MoM is time consuming due to multiple integral required for calculation of self/mutual impedance and CPU time of $O(N^3)$ for inversion of impedance matrix where N is number of unknowns.

In our researches, sixfold integral for calculation of self/mutual impedance was reduced to triple integral by using coordinate transformation [4] and accuracy of the VIE-MoM was improved by introducing monopole segments [5]. Although CPU time for matrix filling in the VIE-MoM can be reduced by our technique, reduction of CPU time for solving matrix equation is indispensable for analysis of large-scale problems including dielectric object. As a fast direct solver based on simple algebraic operation, characteristic basis function method (CBFM) has been proposed so far but has not been applied to the VIE-MoM [6].

In this paper, dipole antenna in the vicinity of dielectric object is analyzed by the CBFM. Numerical analysis is carried out and accuracy of the input reactance obtained by the CBFM with three types of different block division is estimated.

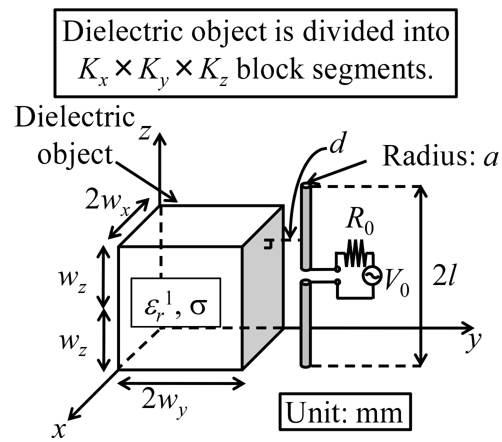

Fig. 1. Dipole antenna in the vicinity of dielectric object.

II. Analysis Model and Block Division in CBFM

As shown in Fig. 1, analysis model is dipole antenna in the vicinity of dielectric object. Richmond's MoM is used and dielectric object is divided into some block dipole and monopole segments. Monopole segments with end point charges are introduced to express normal components of polarization current on boundary between the dielectric object and free space [5]. Number of Gaussian quadrature for calculation of self/mutual impedance between block segments is L.

The CBFM proposed in reference [6] is used in this paper. Accuracy of the CBFM with following three types of different block division is evaluated.

(a) All antenna segments are allocated in the same block and the block of antenna includes part of dielectric object.
(b) All antenna segments are allocated in the same block and the block of antenna includes antenna only.
(c) Antenna segments are allocated in the different block and the block of antenna includes part of dielectric object.

All types of block division are shown in Fig. 2. As shown in Fig. 2, extended block against the original one is defined by extended width w_e and is introduced to improve accuracy of the CBFM.

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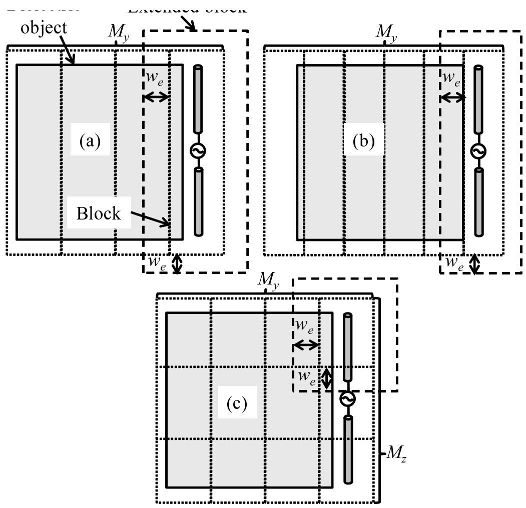

Fig. 2. Three types of block division.

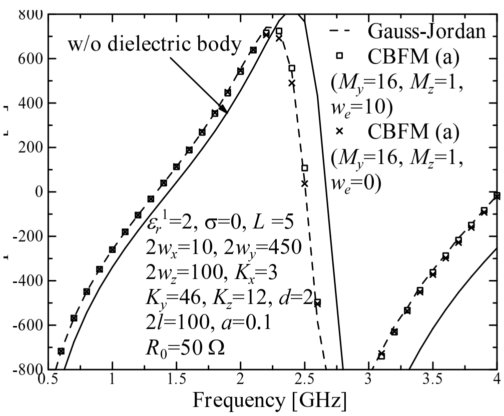

Fig. 3. Input reactance: block division of type (a).

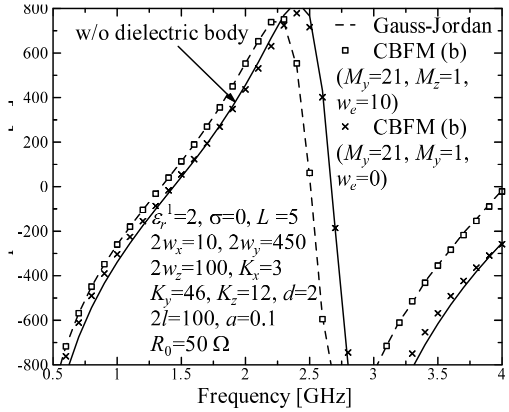

Fig. 4. Input reactance: block division of type (b).

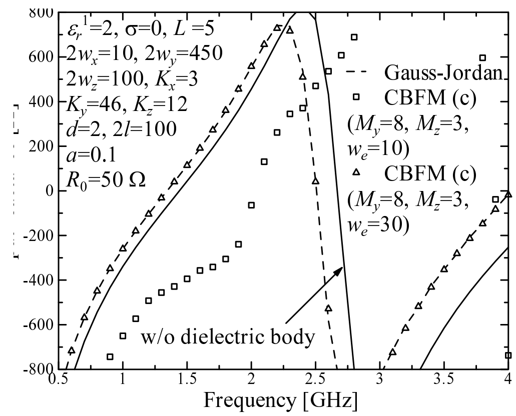

Fig. 5. Input reactance: block division of type (c).

III. Numerical Analysis

Input reactance obtained by the CBFM with different types of block division is shown in Figs. 3 - 5. As shown in Fig. 3, block division of type (a) gives accurate results even when $w_e = 0$ since the block with antenna segments also includes dielectric object in the vicinity of the antenna. On the other hand, block division of type (b) does not give accurate results when $w_e = 0$ since the block with antenna segments does not include dielectric object in the vicinity of the antenna. Based on above discussion, it is found that the block for antenna segments should include polarlization current in the vicinity of the antenna. From Fig. 5, it is found that the CBFM with block division of type (c) produces large error and larger extend width w_e is required for obtaining accurate results. It is thought that the CBFM with the block division of type (c) produces large error since the block division of type (c) is across the current path on the antenna. Therefore, it can be said that the block division across the main current path on the antenna should be avoided in the CBFM.

IV. Conclusions

In this paper, dipole antenna in the vicinity of dielectric object was analyzed by the CBFM with three types of different block division. It was found that all antenna segments should be allocated in the same block and the block should also include dielectric object in the vicinity of the antenna for accurate results.

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