Numerical Analysis of Antenna near Dielectric Object by Using CBFM with Arbitrary Block Division

Keisuke Konno and Qiang Chen
Department of Communications Engineering
Graduate School of Engineering, Tohoku University
Sendai, Miyagi, Japan
konno@ecei.tohoku.ac.jp

***Abstract*—An antenna in the vicinity of dielectric object is analyzed by the characteristic basis function method (CBFM) with arbitrary block division. Numerical examples show the accuracy and computational cost of the CBFM. It is shown that higher-order CBFs beyond the tertiary CBFs ehnance the accuracy of the final solution with small increase of computational cost.**

I. Introduction

Method of moments (MoM) is one of the powerful techniques for analysis of radiation and scattering problems [1], [2]. When the conventional direct solver such as Gauss-Jordan method is used for calculating inverse matrix, computational cost of the MoM is proportional to N^3 where N is the number of unknowns. Because the computational cost of $O(N^3)$ is too large for analysis of large-scale problems, various fast solvers have been proposed instead of the conventional direct solvers.

Characteristic basis function method (CBFM) has been proposed as a fast direct solver[3]. In the CBFM, the original matrix equation is reduced to the smaller one by using linear algebraic operations and the resultant reduced matrix equation is solved by the conventional direct solver. The CBFM has been applied to the analysis of various problems and its small computational cost has been proven [4]-[7]. On the other hand, the accuracy of the CBFM greatly depends on block division [8]. Especially, it has been shown that the accuracy of the CBFM becomes poor when the block division is arbitrary and antenna segments are allocated to different blocks[9], [10].

In this paper, an antenna in the vicinity of dielectric object is analyzed by the CBFM with the higher-order CBFs. Numerical results show that the CBFM with the higher-order CBFs gives final solution accurately even when the block division is arbitrary.

II. Higher-Order CBFs

In the CBFM, the original matrix equation is reduced by using characteristic basis function (CBF). The CBFs are obtained from block matrix equations. The first-order CBFs (Primary basis) are obtained from block self-impedance matrix equations and the CBFs are the source of the second-order CBFs (Secondary basis). The second-order CBFs are obtained from block mutual-impedance matrix equations and the CBFs are the source of the third-order CBFs (Tertiary basis). Higher-order CBFs beyond the tertiary basis function are obtained from block mutual-impedance matrix equations with voltage vector calculated from lower-order CBFs [11], [12]. Accuracy of the final solution of the CBFM can be enhanced by introducing higher-order CBFs.

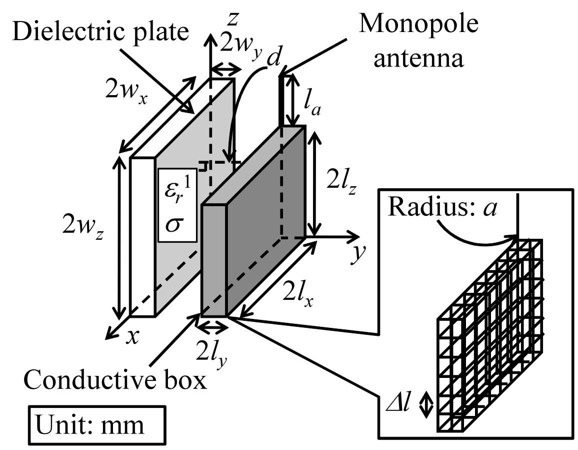

Fig. 1. Monopole antenna on conductive box in the vicinity of dielectric object.

III. Numerical Examples

Monopole antenna on a conductive box in the vicinity of dielectric plate is shown in Fig. 1. Based on the Richmond's MoM, the antenna and conductive box were divided into wire grid segments [2]. The dielectric plate was divided into block dipole and monopole segments. In the CBFM, antenna segments and dielectric segments were allocated to blocks as shown in Fig. 2. It is found that both antenna segments and dielectric segments are allocated to different blocks.

Results of numerical analysis is shown in Fig. 3. It is found that the input reactance obtained by the second-order CBFM ($L = 2$) shows large error compared with that obtained by full-

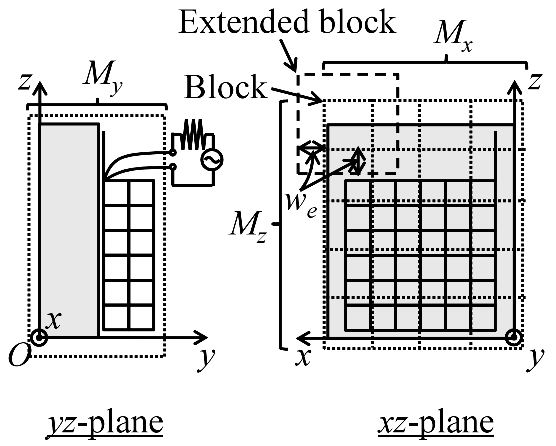

Fig. 2. Block division of antenna and dielectric plate.

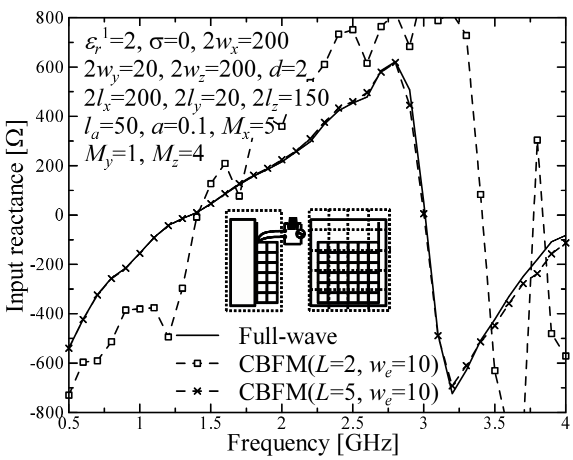

Fig. 3. Input reactance of antenna.

wave analysis. On the other hand, the input reactance obtained by the fifth-order CBFM ($L = 5$) agrees well with that obtained by full-wave analysis. From these results, it is found that the accuracy of the CBFM is enhanced by introducing higher-order CBFM even when the block division is arbitrary and antenna segments are allocated to different blocks. CPU time of the fifth-order CBFM was 1906 seconds while the CPU time of the full-wave analysis was 14602 seconds. Because CPU time of the second-order CBFM was 431 seconds, it is found that the accuracy of the CBFM can be enhanced by introducing higher-order CBFM with small increase of computational cost.

IV. Conclusions

In this paper, an antenna in the vicinity of dielectric object was analyzed by the CBFM with arbitrary block division. Numerical examples showed the accuracy and computational cost of the CBFM. It was shown that higher-order CBFs beyond the tertiary CBFs ehnanced the accuracy of the final solution with small increase of computational cost.

Acknowledgement

We would like to thank the Ministry of Internal Affairs and Communication for the financial support. We would like to thank the Cyberscience Center, Tohoku University.

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