A Study of Novel Characteristic Basis Function Method for Numerical Analysis of Large-Scale Finite Planar Periodic Arrays

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***Abstract*—This paper demonstrates the performance of a novel characteristic basis function method (CBFM) for numerical analysis of a finite planar array antenna. The proposed CBFM uses eigenvectors of a single array element as CBFs in a block. Blocks including the single array element are joined each other and a macro block is obtained. In the same manner, CBFs in the blocks are joined each other and CBFs for the macro block are obtained. Performance of the proposed CBFM, namely, macro block-CBFM (MB-CBFM) is demonstrated via numerical simulation.**

I. Introduction

A periodic array antenna is well known as one of the most popular antenna [1]-[4]. Various numerical analysis techniques for the periodic array antenna have been developed. Periodic method of moments (PMM) is an powerful technique for numerical analysis of the periodic array antenna [5], [6]. The PMM is based on so-called Floquet's theorem and the periodic array antenna is assumed as a unit cell in an infinite periodic array. Self/mutual impedance of the unit cell is obtained using a periodic Green's function and the method of moments (MoM). As a result, the PMM is quite efficient for numerical analysis of the periodic array antenna and its performance has been demonstrated [9]-[11]. One of the disadvantages of the PMM is lack of an edge effect which affects the performance of a finite periodic array antenna. Therefore, an efficient numerical analysis technique for the periodic array antenna including the edge effects is expected to appear.

Recently, our group has proposed a novel MoM for numerical analysis of finite periodic array antennas [7]. The proposed MoM is based on a characteristic basis function method (CBFM) [8]. Two kinds of different blocks are introduced to the proposed CBFM. The first one is a block for the unit cell and the second one is a macro block for a sub-entire domain of the periodic array antenna. The proposed MoM called as a macro block-characteristic basis function (MB-CBFM) includes the edge effect into its results using the macro block at an edge region. In this paper, the performance of the MB-CBFM is demonstrated numerically.

II. MB-CBFM

The MB-CBFM introduces two kinds of blocks. The first one is a block which has already been introduced in the conventional CBFM. In general, the block is composed of a part of antennas or scatterers in the conventional CBFM [8]. On the other hand, the block only includes single array element for the MB-CBFM. Eigenvalue decomposition of the block impedance matrix of the single array element is performed and its characteristic basis functions (CBFs) are available.

The second one is a macro block which has been introduced in [7]. The macro block is composed of a lot of blocks. The CBFs of a single block are joined each other and the CBFs for the macro block are obtained. The MB-CBFM is quite efficient because CBFs for the macro block which cover relatively large domain can be obtained without additional computational cost. Computational cost of the MB-CBFM is $O(N)$ where N is the number of total unknowns. The interested readers can refer to [7] in order to know detailed algorithm of the MB-CBFM.

III. Numerical Examples

A 10×10 array of a mictosrtip Jerusalem cross shown in Fig. 1 was numerically analyzed. A MoM with a layered media Green's function (LMGF) was used for numerical analysis [12], [13]. A RWG(Rao-Wilton-Glisson) basis function was used as basis/testing functions [14]. Effect of singularity of the Green's function on the self/mutual impedance was extracted via coordinate transformation and analytic integral [15], [16]. A so-called Sommerfeld integral for the LMGF was interpolated via Taylor expansion [17].

A bistatic radar cross section (BRCS) pattern of the 10×10 array is shown in Fig. 2. The BRCS obtained using the MB-CBFM is in good agreement with that of the full-wave analysis except for sidelobe level because the sidelobe level is relatively sensitive to small difference of current distribution rather than main lobe level. Total CPU time of the MB-CBFM was only 176 sec. while that of the full-wave analysis was 78,703 sec.

IV. Conclusions

In this paper, the performance of a novel characteristic basis function method, namely, MB-CBFM has been demonstrated.

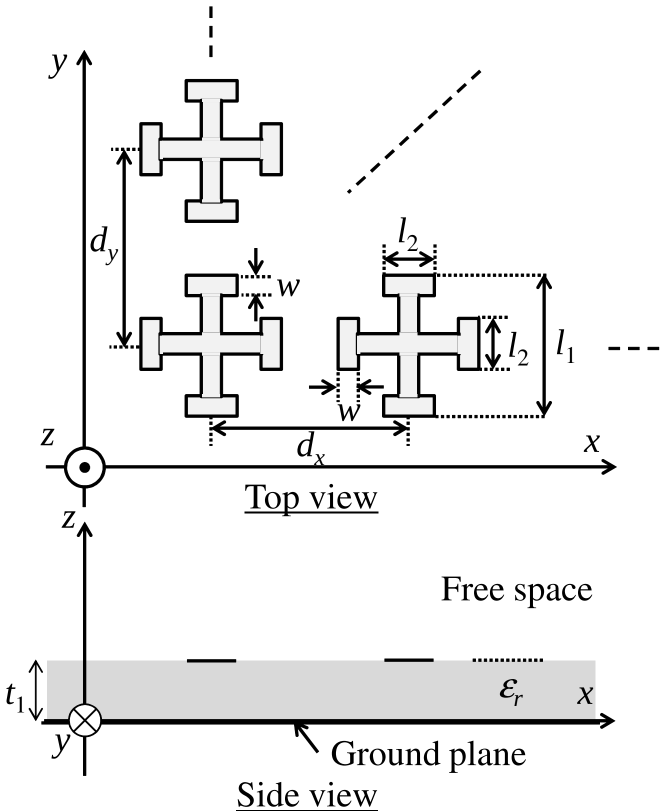

Fig. 1. Jerusalem cross array on a dielectric substrate.

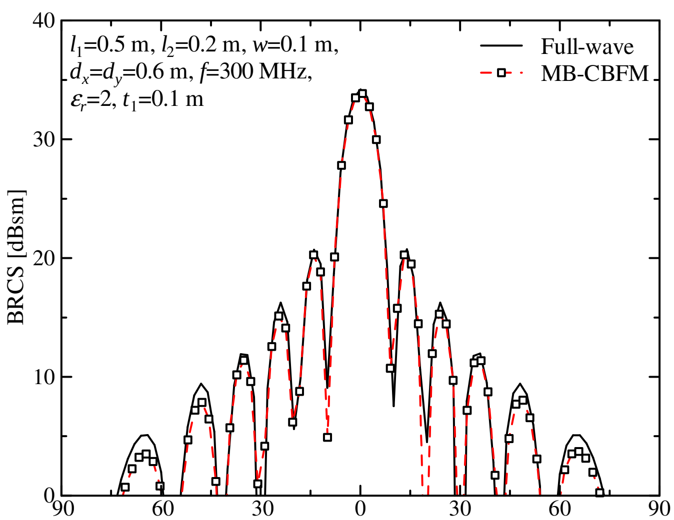

Fig. 2. BRCS pattern of a 10×10 array of microstrip Jerusalem cross (N=12,000, Normal inciedence of TM_z plane wave).

The MB-CBFM is helpful for numerical analysis of a periodic array antenna because computational cost of $O(N)$ is achievable without losing the edge effect on its numerical results [7]. Performance of the MB-CBFM has been clarified via numerical simulation of a planar array antenna.

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