An Efficient Band Diagonal Preconditioner for Electromagnetic Integral Equations Using Wavelet Packet Bases

A. Geranmayeh
Amirkabir University of Technology, Iran

Iterative methods are commonly used to solve large scale moment matrix equations resulting from electromagnetic integral equations. The computational cost of iterative solutions is proportional to the moment matrix-vector multiplication operation and the number of iterations required for a convergent solution [1]. The wavelet (packet) basis functions have been deployed to reduce the computational complexity and memory requirement of dense matrix-vector multiplications operation [2]. The total solution time, however, remains dependent on the number of iterations required to achieve an accurate solution. In case the moment matrix is not well conditioned, an approximate-inverse preconditioning matrix is desired to accelerate the convergence rate of the iterative solution [1].

The use of conventional basis functions results in a dense matrix equation, making it difficult to find an effective approximate-inverse preconditioner. In order to find an appropriate preconditioner more easily, one can transform the moment equation to multiresolution wavelet domain so as to make the transformed moment matrix sparse and diagonal dominant [3, 4]. In most previous studies, the approximate-inverse preconditioner have been designed and constructed in the space domain from a block-diagonal approximation of the sparsified moment matrix [3–5]. The significant elements of the transformed moment matrix, however, are located along the near-diagonal positions, as most offdiagonal entries are negligible due to the vanishing moments of bases in wavelet domain [2]. As a result, a more efficient preconditioner can be constructed that consists of only the near-diagonal terms of the transformed matrix.

This paper proposes a band diagonal approximate inverse matrix preconditioning to overcome the complexity and memory bottlenecks in direct computing the inverse of the original matrix in designing the commonly used preconditioners. Additionally, in order to minimize computational cost and memory requirements in preconditioning operation, the multiplication of the preconditioner and the transformed matrix is carried out in sparse scheme [1]. An electrically large gull-shaped piecewise linear antenna excited by a center-fed voltage is analyzed to investigate the computation efficiency of the proposed method. The governing thin-wire electric field integral equation [2] is solved by the wavelet-based moment method to evaluate the current distribution over the antenna. Numerical results show that the iteration numbers for solving the transformed moment matrix equation preconditioned in wavelet domain by the proposed band diagonal matrix are smaller than those preconditioned by the block-diagonal equivalent one designed in space domain [4].

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