An iterative FEM with fast multipole updates for scattering from a large 3D cavity-backed aperture

Jongkuk Park*, Jungwon Lee**, Sangwook Nam**, Hyunggi Na*, and Jonghoon Chun*
*R&D Group, LG Innotek Co., Ltd.
**School of electrical engineering, Seoul National University.

An iterative FEM for a large body problem is proposed and applied to scattering by a long 3D crack or cavity-backed aperture. At first, the Dirichlet condition has been selected as a boundary condition used by an iterative FEM. However, this choice has been found to be not suitable for characterizing the scattering by an object such as a cavity or a scatterer with a resonant size since the Dirichlet boundary condition causes internal resonance to occur and this internal resonance corrupts a true solution unfortunately. To alleviate this problem, the iterative FEM in conjunction with a radiation-type boundary condition has been suggested and successfully applied to analyzing a 3D cavity-backed aperture(J. Park, J. Lee, H. Chae, and S. Nam, *IEEE Trans. Microwave Theory Tech.*, 2001, **44**, (12), pp. 2145-2151). In the above paper, it is shown that the iterative FEM has good properties that the system matrix preserves its sparsity which the typical FEM generates, and it does not change during iterations. Besides, a matrix for updating a residual field quantity on the artificial boundary is also invariant during iterations, so that it is computed only once at the first iteration. However, this method would fail if it is applied to scattering by an electrically large aperture since a matrix for updating the residual is represented by an integral equation with Green's function, and thus it is a full matrix. Therefore, in order to extend the iterative FEM to a large body problem, in this paper, a fast multipole method is applied to the field updating by an integral equation so that the increasing rate of computation time and memory requirements for updating procedure may decrease. Also, the almost optimal distance for the convergence of this method between the boundary where meshes are terminated and the aperture surface is determined through the numerical experiments. Since this determined value of the distance is found relatively small, the excessive increase of unknowns does not occur as the size of a scattering aperture. Hence, a sparse system matrix makes the FEM procedure efficient enough, and the fast multipole updates enables the computational time and memory requirements to be reduced to the lower order than $O(N_s^2)$, where N_s is the number of unknowns on the boundary. To verify the proposed method, scattering by a long crack is analyzed as a simple example. The result is compared with the typical FEBIM and shows an efficiency and a good agreement.