Accuracy of the Calderon Preconditioned EFIE for the Scattering by PEC Junctions

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The BEM discretised EFIE provides a versatile and accurate approach to the modelling of the scattering of time-harmonic electromagnetic fields by PEC structures. Its domain of application has been extended to include the scattering by closed and open surfaces, and the scattering by surfaces that may contain geometric junctions, i.e. lines along which three or more surfaces meet. Such surfaces are commonly encountered in e.g. the modelling of wings, turbines, cooling fins, backplanes, printed circuit boards, etc.

Upon discretisation, the EFIE yields a system of linear equations. When the description of either the geometry or the solution requires many degrees of freedom, iterative solution of this system is the only course of action given the limited time and memory resources available to the modeller. The time it takes to solve the system iteratively is proportional to the number of iterations required to reach an approximate solution. The number of iterations in turn is very sensitive to the distribution in the complex plane of the eigenvalues of the system matrix.

The distribution of eigenvalues and the number of iteration can be optimised by preconditioning. When limited to the scattering by structures not containing junctions, Calderon preconditioning provides an optimal preconditioner. The construction of a Calderon preconditioner relies critically on the identification of a finite element space, dual to the primal finite element space used in the classic formulation of the EFIE. For primal spaces on non-junction structures, the Buffa-Christiansen (BC) functions provide a basis for this dual space.

Recently, the dual basis of BC functions has been generalised to cover the case of a structure containing junctions. This generalisation requires both the judicial modification of the original BC basis functions and the addition of new BC type basis functions attached to degrees of freedom that live on the junction. It is important to note that the resulting CP-EFIE is not a preconditioned version of the classic EFIE but in fact a non-equivalent linear system with a different solution.

In this contribution, the algorithmic details of the CP-EFIE on junction containing structures are discussed and a careful analysis of the accuracy is performed. This is non-trivial as exact solutions or even error controlled approximations for the scattering by junction type structures are few and far between. It will be shown that the CP-EFIE solution converges rapidly to the solution of the classic EFIE, and this in a much smaller number of iterations.