

Fast Direct Solvers in Computational Electromagnetics

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In this lecture, recent advances in fast direct solvers of $O(N)$ (optimal) complexity will be presented, including both direct partial differential equation (PDE) and integral equation (IE) solvers, for addressing the ultra-large problem size encountered in the integrated circuit design problems. In these solvers, the underlying dense or sparse system matrix is directly inverted or factorized in $O(N)$ complexity. To show how these solvers work, a series of new accuracy-controlled fast matrix arithmetic will be elaborated including the representation of a dense matrix of $O(N^2)$ elements using $O(N)$ parameters with controlled accuracy, subsequent matrix factorization, and inversion performed in $O(N)$ complexity with directly controlled accuracy. The application of these fast algorithms to the design and analysis of industry product-level integrated circuits and systems will be presented. Comparisons with direct and iterative solvers in the past will be made, which demonstrate the clear advantages of the new $O(N)$ direct solvers.