Frequency-domain Concurrent Complementary Operators Method (C-COM) for Finite Element Simulations

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The Complementary Operators Method (COM) and its concurrent version, the Concurrent Complementary Operators Method (C-COM) have been shown to provide very high degree of absorption even for angles incident on the computational boundary at near grazing incidence. In previous works, the C-COM was applied to the finite-difference time-domain (FDTD) method and to the finite-difference frequency-domain (FDFD) method. The strength of the COM and C-COM is that they can fully cancel the first-order reflections that arise when the computational domain is terminated with an absorbing boundary condition (ABC). The cancellation results from the averaging of the two solutions arising from the two independent but complementary operations. The C-COM is more effective because the averaging can be done concurrently. Because of their high accuracy and implementation simplicity, the COM and C-COM operators have been successfully applied to open-region electromagnetic scattering problems, radiation problems and optical beam propagation problems. In this work, we extend the theory of the C-COM to two-dimensional finite element algorithms. We present the formulation of the complementary operators in a finite element paradigm and discuss mesh shape constraints that are relevant to the application of the averaging perimeter. We present numerical results and comparison with other boundary conditions including the perfectly matched layer (PML). Finally, we discuss computational burdens associated with the implementation.