Summary

In computational electromagnetics, phenomena such as wave propagation, radiation and scattering can be modeled through a variety of integral equations. Using the Boundary Element Method (BEM), these equations can then be solved numerically with computers. Unfortunately, integral equations are usually prone to instabilities under certain simulating conditions. For instance, one of the most employed formulation is the Electric Field Integral Equation (EFIE), which is adapted to model metallic objects as Perfect Electric Conductors (PEC). This formulation is however affected by breakdowns at low and high frequencies that result in detrimental consequences on the performance of the solver. More precisely, the condition number of the EFIE matrix obtained in those cases increases, which in turn impacts the accuracy of the solution and the convergence speed of iterative solvers.

This thesis provides an in-depth investigation of scenarios at low and high frequencies and presents stable and accurate original BEM integral equations. One of the research axes involves low frequency simulations of lossy conductors for the modeling of eddy currents. A strategy employing quasi-Helmholtz projectors is devised based on an asymptotic study of the Poggio-Miller-Chang-Harrington-Wu-Tsai (PMCHWT) equation. The second part focuses on high frequency problems for PECs. A theoretical analysis of the eigenvalues of integral operators in two dimensions is presented using Fourier modes. A novel Combined Field Integral Equation (CFIE) is then proposed for reliable and resonance-free simulations at high frequency for the case of the canonical infinite cylinder.