Current distribution and Internal Impedance of Interconnect

The quasi-static approximation is widely used in practical engineering problems like analysis of current carrying conductors, and internal impedance of conductors. The volume integral equation (VIE) for the current within a conductor are very easy to develop by using quasi-static approximation, and the current distribution over cross section can be calculated by use of method of moments (MoM) with pulse basis functions and Galerkin’s method. Surface integral equation (SIE) can also be used to calculate the surface equivalent currents along the boundary of a conductor, and then get the current distribution within the conductor by using these surface equivalent currents to calculate the electric field everywhere inside the conductor. Given the same excitation source, the numerical results calculated from VIE and SIE should be the same, but we found there is a constant ratio between them.

We derive the accurate VIE rigorously for the current distribution within a conductor with arbitrary cross section, and show the different partial differential equations (PDEs) obtained in quasi-static approximation and rigorous approaches require different Greens functions to get the solutions: logarithm and Hankel function, respectively. By expanding the Hankel function for small arguments, two more leading terms should be added into the quasi-static VIE’s integral kernel to cancel the constant ratio mentioned above. Numerical results of a square conductor by using the quasi-static VIE, accurate VIE, and SIE are given.