Novel Acceleration approaches of accurate and efficient modeling of high speed interconnects in layered media

Accurate model of interconnect structures is an importance issue in modern high frequency circuit and chip design. Such as the accurate computation of the frequency dependent internal impedance of interconnect structures, like wires and conducting strips. And the accurate and efficient electromagnetic (EM) modeling for shielded microstrip structures, especially in multilayered medium.

A rigorous volume integral equation (VIE) is developed for the current distribution over two-dimensional conducting cylinder. For very low frequency, it can be reduced to the widely-used quasi-static approximation. The different VIEs, surface integral equation (SIE), and partial differential equation (PDE) with Dirichlet boundary condition method are used to calculate the current distribution. The VIE with quasi-static approximation for good conductor is not accurate enough for the current distribution as there is a constant ratio between the results calculated from the quasi-static VIE and SIE. Two more leading terms from the Hankel function have been added into the integral kernel to solve this problem. We also calculate the internal impedance by using the different VIEs and the PDE with Dirichlet boundary condition method. The different results between VIE and PDE methods are due to the different boundary conditions.

A novel acceleration approaches for spectral domain approach (SDA) over single layer substrate and for spectral domain immitance approach (SDIA) over multilayered substrate has been developed using one of the most promising extrapolation method--the Levin's transformation. It avoid the leading term extraction of the Green's function and the Bessel's functions (basis functions) by recasting the summation kernel to a suitable form which can be applied in the Levin's transformation. The extrapolation delay has been introduced to successfully apply the Levin's transformation. Accurate results have been obtained for the propagation constant by only using twenty or thirty terms. The final accuracy could be further improved if only the first leading term added with the Levin's transformation. The new techniques match with or are even better than other acceleration techniques with high order leading term extraction. The two-dimensional PMCHWT formulation was developed from internal and external equivalent problems, along with the spatial and spectral domain dyadic Green's functions to deal with the arbitrary cross section and finite conductivity of multiple metal lines over multilayered substrate. The pulse and triangular basis were chosen to be applied in the Galerkin method. The matrix elements were calculated from spatial domain integration in internal equivalent problem, while in external equivalent problem we need to transfer the spatial domain integration into spectral domain summation.