Fast Design of Terahertz Plasmonic Devices using Unconditionally Stable Finite Difference Time-Domain Methods

S. Bhardwaj*
Electrical and Computer Engineering Dept., Florida International University,
10555 W. Flagler Street, Miami, FL 33174

With growing applications of terahertz technology, high performance RF devices are needed for implementation of terahertz systems, such as imaging, communication and radar systems. Such RF devices cannot rely on traditional transistor technology, since transistor gate-length scaling becomes challenging for operation beyond 1 THz. Therefore, alternative solutions are being pursued. Among these, devices using electronic-plasmonic oscillations in 2DEG have gained interest in recent years. These devices utilize the 2DEG oscillations to enable various RF operations, such as detection and mixing. For accurate modeling of such devices, rigorous computational models are needed that can account for wave-propagation as well as electron transport within these devices.

Finite difference time domain (FDTD) based hybrid coupled solvers, combining the solution of the electrodynamic and hydrodynamic equations are often used for this problem. Note that, at terahertz frequencies, the plasma-wave oscillations are dominant in 2D electron channel and the model requires much finer ($\approx$ 10-100 times smaller) mesh. Fine mesh sizes lead to small time-steps, as per Courant Condition, leading to long simulation times.

Here, we solve the time-cost issues by introducing ADI (Alternate Directional Implicit)-FDTD and iterative-ADI-FDTD based hybrid coupled solver. They are respectively named as ADI-FDTD-HD and *it*-ADI-FDTD-HD methods. In ADI-FDTD-HD model, the computational efficiency is achieved using unconditional stability, but modeling errors are observed due to truncation of the second order time-step term. Following that, the accuracy of the model is then further improved by using the iterative method that allows correction of the truncated term. Overall, we report the best-case time-reduction of 50%, with a nominal 3% truncation errors for the considered devices at 5 THz. An examination of the proposed methods, including modeling challenges, performance optimization and specific results will be reported at the conference.