Hybrid Algorithm for High Power Microwave Source/Antenna Simulation

Andrew D. Greenwood and Matthew T. Bettencourt
Air Force Research Laboratory/Directed Energy Directorate
Kirtland AFB, NM

High power microwave (HPM) sources involve complex interactions between electromagnetic fields and charged particles. Simulation of these devices is accomplished with particle in cell (PIC) methods. Most PIC methods, including the Improved Concurrent Electromagnetic Particle in Cell (ICEPIC) code, use the Yee finite difference time domain (FDTD) method to model the electromagnetic fields. Time domain techniques are needed to correctly model nonlinear interaction between the charged particles and the electromagnetic fields. ICEPIC is used very successfully for HPM source simulation. However, when an antenna is added to the HPM source, the tensor grid required by the FDTD technique may have difficulty resolving small features. Further, many antenna and platform modeling tools operate in the frequency domain.

The high performance computing modernization program (HPCMP) is currently investing in antenna and platform modeling tools through the virtual electromagnetic design (VED) portfolio. Like many other antenna and platform modeling tools, the tools under VED development operate in the frequency domain. To enable end to end HPM device simulation, including antenna and platform interaction, a time/frequency domain hybrid interface is under development and is being implemented within ICEPIC and the frequency domain VED tools.

The interface assumes that the HPM source and its antenna are connected through a hollow waveguide with a few propagating modes. This allows the VED tools to compute a table of reflection coefficients for these propagating modes and eliminates the need for the ICEPIC computation grid to align with the frequency domain VED grid. The reflection coefficients are computed over the band of frequencies present at the HPM source output, and ICEPIC transforms them to the time domain using the fast Fourier transform (FFT) and uses the resulting data to compute and launch the modes reflected by the antenna.

The presentation gives more detail of the connection algorithm and discusses the current status of implementation and testing.