Dual Polarized Phased Array Antenna Simulation Using Optimized FDTD Method with PBC

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Objectives

The motivations to develop own fast and accurate phased array antenna simulator are: (1) since the source code is available, it is easy to introducing new features to do pattern predictions (2) high performance and expensive computer clusters are needed for massive multifunctional phased array antenna simulation using commercial software. In this work, initial results of development of a finite-difference time-domain (FDTD) simulator (called PASim) for dual polarization phased array antenna is presented. The numerical model is based on periodic boundary condition (PBC), which handles finite phased array antenna and reduces vast amount of computational time compared to some other finite array simulation tools.

Theory

The updating equations, updating coefficients, absorbing boundaries, radiating boundaries, voltage, and current probes/sources can be evaluated using standard FDTD updating equations except at the locations of periodic boundaries. For example, the updating equation for $E_x$ and $E_z$ at the $x = 0$ and $x = x_p$ periodic boundaries can be evaluated in the time marching loop as

$$E_{x}^{n+1}(x,y,z) = C_{ex}(x,y,z)E_{x}^{n}(x,y,z) + C_{exy}(x,y,z)\left[H_{y}^{n+\frac{1}{2}}(x,y,z + 1) - H_{y}^{n+\frac{1}{2}}(x,y,z)\right]$$

$$E_{z}^{n+1}(x,y,z) = C_{ez}(x,y,z)E_{z}^{n}(x,y,z) - C_{exz}(x,y,z)\left[H_{x}^{n+\frac{1}{2}}(x,y,z) + H_{x}^{n+\frac{1}{2}}(x,y,z)\right]$$

For a specific example result, an 8x8 array was simulated using HFSS and a MATLAB/C++/Java versions of PASim program and an 8x8 wide band array was simulated using PASim and measured in a Near-Field Chamber at OU-RL. For the 8x8 array results, The measurements was taken in the range of $V \in [0,0,0,0]$ and $V \in [-0,0,0,0]$.

Conclusion

The performance of the PASim is very promising according to the benchmark result in Table 1. For 4x4 array results, there is a good agreement between PASim and HFSS. Co Polarization from PASim is slightly higher than HFSS results. Since we have full control of the source code, there are multiple ways to further improve the full-wave simulation accuracy. Implementation of PASim with PBC for simulating wide band array with steering beam will be the next step with high priority. Since none-periodic excitation in beam forming is a necessary in phased array antenna, introducing Array Scanning Method (ASM) is another milestone to be achieve. Modifying PASim for cylindrical coordinates is highly desired. Using GPU to accelerate the computation is also part of future plan.

References


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