

Modeling of Periodic Structures using Finite-Difference Time-Domain Technique

Guiping Zheng, Ahmed A. Kishk, Allen W. Glisson, and Alexander B. Yakovlev

Department of Electrical Engineering
Center for Applied Electromagnetic Systems Research (CAESR)
The University of Mississippi, University, MS 38677, USA

Abstract: In this work, numerical analysis of periodic structures based on the finite difference time domain (FDTD) method is presented. Many electromagnetic structures have the properties of periodicity in one or two dimensions, such as frequency selective surfaces (FSS), photonic bandgap (PBG) structures, and infinite antenna arrays. The FSS structures have been widely used to construct a high impedance ground plane. By using a high impedance ground plane, the performance of antennas can be greatly improved. The FDTD technique has been successfully used to obtain the numerical solution without resorting to the complex frequency domain analysis required in the Method of Moments (MoM). There are several different methods to model periodic structures in FDTD. One of these methods is the field transformation method. In the field transformation method, Maxwell's equations are transformed and modified by using transformed fields, and because of the periodicity, only the fields in the "unit cell" are unique and needed to be determined in the FDTD. The coupling effects from the other unit cells are properly treated by applying the periodic boundary conditions in the FDTD. Therefore, the field transformation method is much more efficient than other methods that require multi-unit-cells or complex algorithm. Difficulties to implement periodic boundary condition in the FDTD, related to the time-delay and time-advanced concept, can be overcome by applying a simply periodic boundary condition in field transformation method. Thus, the field transformation method is the most efficient way to model the periodic structures among all the numerical methods in FDTD. Several validation cases including FSS and infinite antenna arrays will be presented.