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FDTD METHOD AND ANTENNA DESIGN

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Abstract

FDTD method is a computational tool. It has interesting features, such as easy programming and broad band calculations which make it preferable over frequency domain calculations in many cases. This paper discusses problems which are special to FDTD methods including excitation, absorbing boundary conditions, and geometrical problems, when the method is used to solve antenna problems.

Introduction

Use of FDTD in EM problems was first demonstrated by Yee in 1966 [1]. Unfortunately, the paper was published before the computing public was ready to accept it. The large machine was not available and the antenna engineers were too busy with the method of moment. The real demonstration of the power of the FDTD was down by Taflove in 1975 [2]. A sequence of papers associated with EMP using FDTD were published later [3][4]. At that time the Cray machine was not yet available, so the 3-D scattering problems that were solved, were quite rough. With the birth of supercomputers, the power of the FDTD method really starts to show. It was able to solve large scale problems involving localized sources, such as full wave analysis of microstrip components [5] and patch antennas [6][7]. Because of its simplicity, the FDTD method is easy to program and results in great savings in human time. But, there are problems one has to deal with when using the method, which are discussed in the following.

Source Excitation

An antenna problem is different from a scattering problem in that the source is localized and attached to the antenna body. In frequency domain, especially using the method of moment, the source is easily represented. In FDTD the source may be the imposed field at one end of a transmission line, such as shown in Fig. 1. In that configuration, if a spacially distributed Gaussian pulse were used as the source field at that plane, the surface becomes a short circuit, when the pulse passes. And, hence it becomes a reflecting surface, not a matched generator. The problem is particularly accute when the antenna is reactive and the signals oscillate inside the antenna structure. In that case instability may occur.

To alleviate the above problem, we need to switch the boundary condition of the excitation plane to an absorbing boundary condition after the pulse has passed and before the reflection comes back. That absorbing surface is often more conveniently placed in front of the excitation plane.

Absorbing Boundaries

The absorbing boundary is like an original sin for the FDTD method. One is never able to solve it exactly. We can only try to minimize the boundary reflections. All absorbing boundary conditions are physical conditions, assuming wave propagations in particular directions. There are many methods to impose absorption of which some are quite simple and some are very complicated [8, 9, 10]. This talk will discuss a technique called the "Superabsorption Technique," where a simple crude absorption technique can be easily manipulated to become a very good one.

Geometry

The FDTD method is most easily applied to boundary geometries which are basically rectangular. Recent work by Mei, et al. [11] on flare antennas is the only one that treats non-rectangular antennas. Even that case is not general, in that the antennas are made of flat sheets. There is no easy way to treat arbitrarily shaped 3-D antennas. Recent work by Yee, et al [12] has shown a great progress in that direction.

Conclusion

The FDTD method has many interesting attractive features and has several drawbacks. One attractive feature is its ability to obtain broadband data from a single calculation. Associated with this attractive feature is the need to perform Fourier Transform of the time domain results. And, the Fourier Transform turns out to be very sensitive to the reflection error of the absorbing boundary. When experiences accumulate and problems are licked we shall see more and more usage of the FDTD method in antenna calculations.

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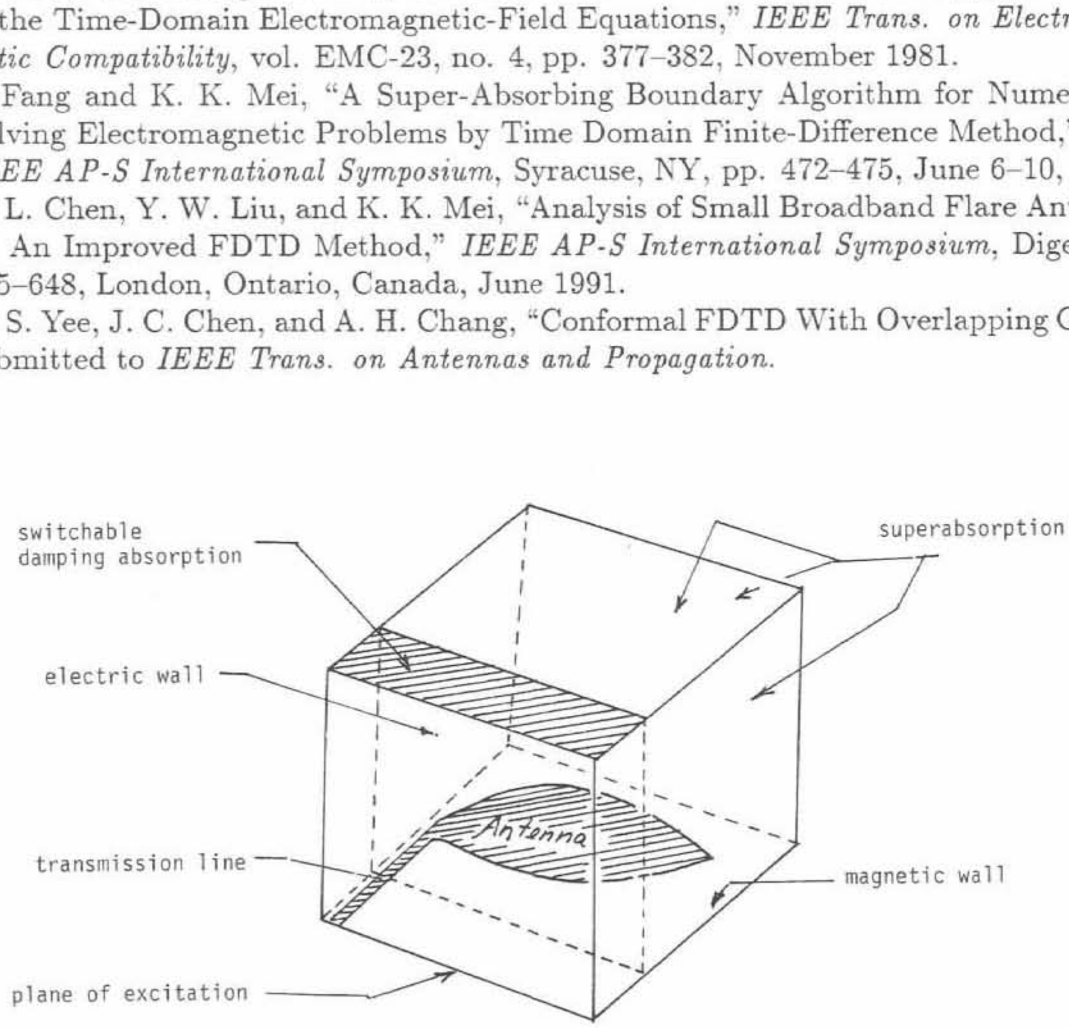

Figure 1. Particulars of computing region of an antenna using the FDTD method.