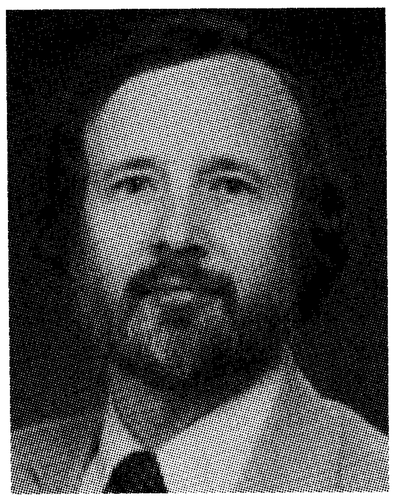

Allen Glisson
Dept. of Electrical Engineering
University of Mississippi
PO Box 1848
University, MS 38677-1848 USA
+1 (662) 915-5353
+1 (662) 915-2731 (Fax)
aglisson@olemiss.edu (e-mail)

Computational Electrodynamics: The Finite-Difference Time-Domain Method (Third Edition), by Allen Taflove and Susan C. Hagness, Norwood, MA, Artech House, 2005, xxii +1006, $139.00, ISBN 1-58053-832-0.

The third edition of this book follows in the footsteps of previous editions, in providing a comprehensive reference both for the basic Finite-Difference Time-Domain (FDTD) method, and also for many of the major enhancements that have been developed over the last decades. In view of the huge number of publications that exist, and the large and increasing number of people who are working on developing and efficiently applying FDTD algorithms, such a reference is invaluable.

It is an ideal starting point for beginners in the FDTD method, as well as a handy reference for more experienced practitioners. Many graduate students and final-year undergraduates in this Department have benefited greatly from reading the parts of previous editions of this book that are relevant to their work. Each chapter concludes with a list of instructive exercises and projects, which makes the book very useful in the area of teaching.

As with the previous edition, each chapter is written by acknowledged experts in their own particular aspect of FDTD research and application. This ensures that the most up-to-date information is available. Much new material has been added since the publication of the second edition, and this reflects the substantial rate of progress that is being made in this area of research.

The second edition included a CD, which contained PDF files of the figures used in the book, a *FORTRAN* program that implemented the Dey-Mittra algorithm, and some *MATLAB* code. The third edition does not contain a CD, but, instead, the reader is pointed to a Web site from which a variety of downloads can be obtained if requested. These include *FORTRAN* codes for one-dimensional, two-dimensional, and three-dimensional FDTD with various flavors of PML boundary conditions. Solutions to the problems in the book are available for "instructors," if a written request on headed notepaper is submitted.

The material in the book is logically structured, starting with the basics of finite-difference methods, and leading through to advanced and specialized algorithms and to demanding applications. After a preface – which itemizes the new material included in this edition over and above that which was included in the second edition – the first chapter sets the scene by giving a general introduction to computational electromagnetics and its context in the twenty-first century. This is followed by an account of the historical development of the FDTD method, and a summary of the range of applications for which FDTD is currently being used.

The second and third chapters give a detailed treatment of the basic FDTD algorithm, starting with the one-dimensional scalar wave equation and building up to the three-dimensional Yee algorithm, which is the basis for all that follows. In addition, a brief but useful introduction is given to some of the alternative formulations, including the contour-path interpretation of FDTD and the use of non-cubical grids. These aspects are treated in greater depth in subsequent chapters.

The third chapter concludes with an account of what is perhaps one of the more unusual applications of FDTD, namely the modeling of the planet Earth from the point of view of ELF transmission. This illustrates well the fact that FDTD is a tool that can be applied at all frequencies, including the ultra-low as well as the more usual RF to optical range.

Having described the basic algorithms, their general properties are examined in Chapter 4, particularly in regard to numerical dispersion and stability. The dispersion characteristics of the Yee mesh are derived and the formulae are presented. Methods of reducing the dispersion and non-isotropy of the mesh by using a fourth-order-in-space scheme are also described in detail and, as throughout the book, there are ample references to published papers for those who require more detail.

Chapters 5, 6, and 7 are devoted to algorithms that would be essential to almost every implementation of a practical FDTD tool, namely excitation from various sources and absorbing boundary conditions (ABCs). All the information needed to implement the various types of possible ABCs, such as one-way wave equations, complementary ABCs, and perfectly matched layers (PML) is available here. In the case of the PML, this includes hints on how to program in an efficient manner. A number of *FORTRAN* code fragments are provided, which assist in this area.

The remaining chapters provide details of more specialized algorithms that would be required in some but not all implementations. Many of these areas are the subjects of ongoing research, and these chapters form a useful compendium of the major advances and of the current state-of-the-art for those who wish to know what is available without having to do a time-consuming literature search. Subjects dealt with include: near-to-far transformations (Chapter 8), complex materials (Chapter 9), sub-cell techniques for dealing with geometrical detail (Chapter 10), non-Cartesian grids and sub-grids (Chapter 11), bodies of revolution (Chap-

ter 12), periodic structures (Chapter 13), pseudo-spectral techniques (Chapter 17), unconditionally stable (ADI) techniques (Chapter 18), and hybrid techniques (Chapter 19).

A description of a number of sub-cellular techniques is given in Chapter 10. These include the use of the contour-path interpretation of FDTD, originally introduced in the late 1980s, and the Dey-Mittra/Yu-Mittra technique for accurately modeling curved perfect electric conductors (PECs) with little penalty to the computational requirements. Other sub-cellular techniques that are applicable to curved dielectric boundaries, thin dielectric sheets, and to surface impedance boundaries are also described here. Somewhat surprisingly, there is no mention in this chapter of the thin-wire formalism, originally introduced by Holland and Simpson and more recently enhanced by other researchers, although a brief description of this approach is given in Chapter 19.

In addition to this, there are a number of more application-oriented chapters, which deal with the subjects of antennas (Chapter 14), photonics (Chapter 16), and circuits including lumped components and networks (Chapter 15). Case studies are provided to show how the techniques described in the first part of the book can be used or combined in order to provide practical analyses of complex structures. These allow the reader to grasp the type and range of applications that can be tackled using the FDTD method. In Chapter 14, an example is given of the analysis of a standard horn, a slotline Vivaldi array antenna, and a dipole in the presence of a human head.

Chapter 15 includes detailed descriptions of how lumped components, both passive and active, and complete two-terminal lumped linear networks can be included within the FDTD paradigm. A case study is included that shows how these techniques can be applied to a complete packaged 6 GHz MESFET amplifier, which includes the nonlinear large-signal effects. Chapter 16 outlines a variety of applications in optics, many of which involve the modeling of nonlinear and dispersive materials of the type dealt with in Chapter 9.

To sum up, this book is an invaluable reference for FDTD practitioners and researchers, and for graduate and final-year undergraduate students who are starting out on an FDTD-based project. It contains all the information that can be expected in a book of this type given the rate at which research is taking place, and much new material has been added over and above that which was in the previous edition.

Reviewed by:

Prof. Chris Railton
Department of Electrical Engineering
Merchant Venturers Bldg., Woodland Road
University of Bristol
Bristol, BS1 1UB, United Kingdom