

John L. Volakis · Kubilay Sertel · Brian C. Usner

# Frequency Domain Hybrid Finite Element Methods for Electromagnetics

# Frequency Domain Hybrid Finite Element Methods In Electromagnetics Synthesis Lectures On Computational Electromagnetics

**Nikolaos V. Kantartzis, Theodoros D.  
Tsiboukis**



## **Frequency Domain Hybrid Finite Element Methods In Electromagnetics Synthesis Lectures On Computational Electromagnetics:**

**Frequency Domain Hybrid Finite Element Methods in Electromagnetics** John. L Volakis, Kubilay Sertel, Brian C Usner, 2022-06-01 This book provides a brief overview of the popular Finite Element Method FEM and its hybrid versions for electromagnetics with applications to radar scattering antennas and arrays guided structures microwave components frequency selective surfaces periodic media and RF materials characterizations and related topics It starts by presenting concepts based on Hilbert and Sobolev spaces as well as Curl and Divergence spaces for generating matrices useful in all engineering simulation methods It then proceeds to present applications of the finite element and finite element boundary integral methods for scattering and radiation Applications to periodic media metamaterials and bandgap structures are also included The hybrid volume integral equation method for high contrast dielectrics and is presented for the first time Another unique feature of the book is the inclusion of design optimization techniques and their integration within commercial numerical analysis packages for shape and material design To aid the reader with the method s utility an entire chapter is devoted to two dimensional problems The book can be considered as an update on the latest developments since the publication of our earlier book Finite Element Method for Electromagnetics IEEE Press 1998 The latter is certainly complementary companion to this one

**MATLAB-based Finite Element Programming in Electromagnetic Modeling** Özlem Özgün, Mustafa Kuzuoğlu, 2018-09-03 This book is a self contained programming oriented and learner centered book on finite element method FEM with special emphasis given to developing MATLAB programs for numerical modeling of electromagnetic boundary value problems It provides a deep understanding and intuition of FEM programming by means of step by step MATLAB programs with detailed descriptions and eventually enabling the readers to modify adapt and apply the provided programs and formulations to develop FEM codes for similar problems through various exercises It starts with simple one dimensional static and time harmonic problems and extends the developed theory to more complex two or three dimensional problems It supplies sufficient theoretical background on the topic and it thoroughly covers all phases pre processing main body and post processing in FEM FEM formulations are obtained for boundary value problems governed by a partial differential equation that is expressed in terms of a generic unknown function and then these formulations are specialized to various electromagnetic applications together with a post processing phase Since the method is mostly described in a general context readers from other disciplines can also use this book and easily adapt the provided codes to their engineering problems After forming a solid background on the fundamentals of FEM by means of canonical problems readers are guided to more advanced applications of FEM in electromagnetics through a survey chapter at the end of the book Offers a self contained and easy to understand introduction to the theory and programming of finite element method Covers various applications in the field of static and time harmonic electromagnetics Includes one two and three dimensional

finite element codes in MATLAB Enables readers to develop finite element programming skills through various MATLAB codes and exercises Promotes self directed learning skills and provides an effective instruction tool *Principles and Techniques of Electromagnetic Compatibility* Christos Christopoulos, 2022-07-14 This book provides a sound grasp of the fundamental concepts applications and practice of EMC Developments in recent years have resulted in further increases in electrical component density wider penetration of wireless technologies and a significant increase in complexity of electrical and electronic equipment New materials which can be customized to meet EMC needs have been introduced Considerable progress has been made in developing numerical tools for complete system EMC simulation EMC is now a central consideration in all industrial sectors Maintaining the holistic approach of the previous edition of *Principles and Techniques of Electromagnetic Compatibility* the Third Edition updates coverage of EMC to reflect recent important developments What is new in the Third Edition A comprehensive treatment of new materials meta and nano and their impact on EMC Numerical modelling of complex systems and complexity reduction methods Impact of wireless technologies and the Internet of Things IoT on EMC Testing in reverberation chambers and in the time domain A comprehensive treatment of the scope and development of stochastic models for EMC EMC issues encountered in automotive railway aerospace and marine applications Impact of EMC and Intentional EMI IEMI on infrastructure and risk assessment In addition to updating material new references examples and appendices were added to offer further support to readers interested in exploring further As in previous editions the emphasis is on building a sound theoretical framework and demonstrating how it can be turned to practical use in challenging applications The expectation is that this approach will serve EMC engineers through the inevitable future technological shifts and developments *Handbook of Reflector Antennas and Feed Systems Volume II: Feed Systems* Lotfollah Shafai, Satish K. Sharma, Sudhakar Rao, 2013-07-01 This is the first truly comprehensive and most up to date handbook available on modern reflector antennas and feed sources for diversified space and ground applications There has never been such an all encompassing reflector handbook in print and no currently available title offers coverage of such recent research developments The Handbook consists of three volumes Volume II focuses on feed sources Reflector antennas are extraordinary devices that combine high gain with geometrical simplicity and can operate in broad frequency bands Their performance however depends on the electrical characteristics of the feed system with which they operate This comprehensive volume provides you with a solid understanding of feed system theory design and analysis Featuring chapters authored by experts in each aspect of feed systems this book takes you from fundamental mathematical techniques electrically small and large dual reflectors feed geometry and telemetry tracking and command antennas and more Throughout the book numerous examples are provided to guide you in the practical aspects of feed design Science Abstracts ,1993 Frequency Domain Hybrid Finite Element Methods in Electromagnetics John L. / Sertel Volakis (Kubilay / Usner, Brian C.), 2006 **Introduction to the Finite Element Method in Electromagnetics** Anastasis C.

Polycarpou,2022-05-31 This series lecture is an introduction to the finite element method with applications in electromagnetics The finite element method is a numerical method that is used to solve boundary value problems characterized by a partial differential equation and a set of boundary conditions The geometrical domain of a boundary value problem is discretized using sub domain elements called the finite elements and the differential equation is applied to a single element after it is brought to a weak integro differential form A set of shape functions is used to represent the primary unknown variable in the element domain A set of linear equations is obtained for each element in the discretized domain A global matrix system is formed after the assembly of all elements This lecture is divided into two chapters Chapter 1 describes one dimensional boundary value problems with applications to electrostatic problems described by the Poisson s equation The accuracy of the finite element method is evaluated for linear and higher order elements by computing the numerical error based on two different definitions Chapter 2 describes two dimensional boundary value problems in the areas of electrostatics and electrodynamics time harmonic problems For the second category an absorbing boundary condition was imposed at the exterior boundary to simulate undisturbed wave propagation toward infinity Computations of the numerical error were performed in order to evaluate the accuracy and effectiveness of the method in solving electromagnetic problems Both chapters are accompanied by a number of Matlab codes which can be used by the reader to solve one and two dimensional boundary value problems These codes can be downloaded from the publisher s URL [www.morganclaypool.com](http://www.morganclaypool.com) page polycarpou This lecture is written primarily for the nonexpert engineer or the undergraduate or graduate student who wants to learn for the first time the finite element method with applications to electromagnetics It is also targeted for research engineers who have knowledge of other numerical techniques and want to familiarize themselves with the finite element method The lecture begins with the basics of the method including formulating a boundary value problem using a weighted residual method and the Galerkin approach and continues with imposing all three types of boundary conditions including absorbing boundary conditions Another important topic of emphasis is the development of shape functions including those of higher order In simple words this series lecture provides the reader with all information necessary for someone to apply successfully the finite element method to one and two dimensional boundary value problems in electromagnetics It is suitable for newcomers in the field of finite elements in electromagnetics [Index to IEEE Publications](#) Institute of Electrical and Electronics Engineers,1989 Issues for 1973 cover the entire IEEE technical literature

[The Finite Element Method in Electromagnetics](#) Jian-Ming Jin,2015-02-18 A new edition of the leading textbook on the finite element method incorporating major advancements and further applications in the field of electromagnetics The finite element method FEM is a powerful simulation technique used to solve boundary value problems in a variety of engineering circumstances It has been widely used for analysis of electromagnetic fields in antennas radar scattering RF and microwave engineering high speed high frequency circuits wireless communication electromagnetic compatibility photonics remote

sensing biomedical engineering and space exploration The Finite Element Method in Electromagnetics Third Edition explains the method's processes and techniques in careful meticulous prose and covers not only essential finite element method theory but also its latest developments and applications giving engineers a methodical way to quickly master this very powerful numerical technique for solving practical often complicated electromagnetic problems Featuring over thirty percent new material the third edition of this essential and comprehensive text now includes A wider range of applications including antennas phased arrays electric machines high frequency circuits and crystal photonics The finite element analysis of wave propagation scattering and radiation in periodic structures The time domain finite element method for analysis of wideband antennas and transient electromagnetic phenomena Novel domain decomposition techniques for parallel computation and efficient simulation of large scale problems such as phased array antennas and photonic crystals Along with a great many examples The Finite Element Method in Electromagnetics is an ideal book for engineering students as well as for professionals in the field

**Modern EMC Analysis Techniques Volume I** Nikolaos V. Kantartzis, Theodoros D. Tsiboukis, 2022-05-31 The objective of this two volume book is the systematic and comprehensive description of the most competitive time domain computational methods for the efficient modeling and accurate solution of contemporary real world EMC problems Intended to be self contained it performs a detailed presentation of all well known algorithms elucidating on their merits or weaknesses and accompanies the theoretical content with a variety of applications Outlining the present volume the analysis covers the theory of the finite difference time domain the transmission line matrix modeling and the finite integration technique Moreover alternative schemes such as the finite element the finite volume the multiresolution time domain methods and many others are presented while particular attention is drawn to hybrid approaches To this aim the general aspects for the correct implementation of the previous algorithms are also exemplified At the end of every section an elaborate reference on the prominent pros and possible cons always in the light of EMC modeling assists the reader to retrieve the gist of each formulation and decide on his/her best possible selection according to the problem under investigation Table of Contents Fundamental Time Domain Methodologies for EMC Analysis Alternative Time Domain Techniques in EMC Modeling Principal Implementation Issues of Time Domain EMC Simulation *International Aerospace Abstracts*, 1998 *Newsletter*, 1997 **Graduate Catalog** Iowa State University, 1981 **Introduction to the Finite Element Method in Electromagnetics (Synthesis Lectures on Computational Electromagnetics)**. Anastasis C.

Polycarpou, [Finite Element Method Electromagnetics](#) John L. Volakis, Arindam Chatterjee, Leo C. Kempel, 1998-06-15 Employed in a large number of commercial electromagnetic simulation packages the finite element method is one of the most popular and well established numerical techniques in engineering This book covers the theory development implementation and application of the finite element method and its hybrid versions to electromagnetics FINITE ELEMENT METHOD FOR ELECTROMAGNETICS begins with a step by step textbook presentation of the finite method and its variations then goes on

to provide up to date coverage of three dimensional formulations and modern applications to open and closed domain problems Worked out examples are included to aid the reader with the fine features of the method and the implementation of its hybridization with other techniques for a robust simulation of large scale radiation and scattering The crucial treatment of local boundary conditions is carefully worked out in several stages in the book Sponsored by IEEE Antennas and Propagation Society

**Hybrid Methods for Computational Electromagnetics in the Frequency Domain** Stefan

Hagdahl, Institutionen för numerisk analys och datalogi (Stockholm), 2003

Finite Elements, Electromagnetics and Design

S.R.H. Hoole, 1995-05-19 Advanced topics of research in field computation are explored in this publication Contributions have been sourced from international experts ensuring a comprehensive specialist perspective A unity of style has been achieved by the editor who has specifically inserted appropriate cross references throughout the volume plus a single collected set of references at the end The book provides a multi faceted overview of the power and effectiveness of computation techniques in engineering electromagnetics In addition to examining recent and current developments it is hoped that it will stimulate further research in the field

**Finite Element and Finite Difference Methods in Electromagnetic Scattering** M.A.

Morgan, 2013-10-22 This second volume in the Progress in Electromagnetic Research series examines recent advances in computational electromagnetics with emphasis on scattering as brought about by new formulations and algorithms which use finite element or finite difference techniques Containing contributions by some of the world s leading experts the papers thoroughly review and analyze this rapidly evolving area of computational electromagnetics Covering topics ranging from the new finite element based formulation for representing time harmonic vector fields in 3 D inhomogeneous media using two coupled scalar potentials to the consideration of conforming boundary elements and leap frog time marching in transient field problems involving corners and wedges in two and three dimensions the volume will provide an indispensable reference source for practitioners and students of computational electromagnetics

**Modern EMC Analysis Techniques Volume**

**II** Nikolaos V. Kantartzis, Theodoros D. Tsiboukis, 2022-06-01 The objective of this two volume book is the systematic and comprehensive description of the most competitive time domain computational methods for the efficient modeling and accurate solution of modern real world EMC problems Intended to be self contained it performs a detailed presentation of all well known algorithms elucidating on their merits or weaknesses and accompanies the theoretical content with a variety of applications Outlining the present volume numerical investigations delve into printed circuit boards monolithic microwave integrated circuits radio frequency microelectromechanical systems as well as to the critical issues of electromagnetic interference immunity shielding and signal integrity Biomedical problems and EMC test facility characterizations are also thoroughly covered by means of diverse time domain models and accurate implementations Furthermore the analysis covers the case of large scale applications and electrostatic discharge problems while special attention is drawn to the impact of contemporary materials in the EMC world such as double negative metamaterials bi isotropic media and several others Table

of Contents Introduction Printed Circuit Boards in EMC Structures Electromagnetic Interference Immunity Shielding and Signal Integrity Bioelectromagnetic Problems Human Exposure to Electromagnetic Fields Time Domain Characterization of EMC Test Facilities Large Scale EMC and Electrostatic Discharge Problems Contemporary Material Modeling in EMC Applications     **Quick Finite Elements for Electromagnetic Waves** Giuseppe Pelosi, Roberto Coccioli, Stefano Selleri, 2009 The classic 1998 Artech House book Quick Finite Elements for Electromagnetic Waves has now been revised and expanded to bring you up to date with the latest developments in the Field You find brand new discussions on finite elements in 3D 3D resonant cavities and 3D waveguide devices Moreover the second edition supplies you with MATLAB code making this resource easier to comprehend and use for your projects in the field This practical book and accompanying software enables you to quickly and easily work out challenging microwave engineering and high frequency electromagnetic problems using the finite element method FEM Using clear concise text and dozens of real world application examples the book provides a detailed description of FEM implementation while the software provides the code and tools needed to solve the three major types of EM problems guided propagation scattering and radiation With this unique book and software set in hand you can compute the dispersion diagram of arbitrarily shaped inhomogeneous isotropic lossless or lossy guiding structures analyze E and H plane waveguide discontinuities and devices and understand the reflection from and transmission through simple 2D and 3D inhomogeneous periodic structures CD ROM Included Easy to use finite element software contains ready made MATLAB and FORTRAN source code that you can use immediately to solve a wide range of microwave and EM problems The package is fully compatible with Internet freeware so you can perform advanced engineering functions without having to purchase expensive pre and post processing tools



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