Electromagnetic Modeling By Finite Element Methods Electrical And Computer Engineering

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Parallel Goal-oriented Adaptive Finite Element Modeling for 3D Electromagnetic Exploration CRC Press
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.
Renewable Energy for Smart and Sustainable Cities CRC Press
Electromagnetic Modeling by Finite Element MethodsCRC Press
Seismoelectric Exploration John Wiley & Sons
Unlike any other source in the field, this valuable reference clearly examines key aspects of the finite element method (FEM) for electromagnetic analysis of low-frequency electrical devices. The authors examine phenomena such as nonlinearity, mechanical force, electrical circuit coupling, vibration, heat, and movement for applications in the electrical, mechanical, nuclear, aeronautics, and transportation industries. Electromagnetic Modeling by Finite Element Methods offers a wide range of examples, including torque, vibration, and iron loss calculation; coupling of the FEM with mechanical equations, circuits, converters, and thermal effects; material modeling; and proven methods for hysteresis implementation into FEM codes. Providing experimental results and comparisons from the authors' personal research, Electromagnetic Modeling by Finite Element Methods supplies techniques to implement FEM for solving Maxwell's equations, analyze electrical and magnetic losses, determine the behavior of electrical machines, evaluate force distribution on a magnetic medium, simulate movement in electrical machines and electromagnetic devices fed by external circuits or static converters, and analyze the vibrational behavior of electrical machines.

Theory, Experiments, and Applications PHI Learning Pvt. Ltd.
This lecture is written primarily for the non-expert 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 designed for research engineers who have knowledge of other numerical techniques and want to familiarize themselves with the finite element method.Finite element method is a numerical method used to solve boundary-value problems characterized by a partial differential equation and a set of boundary conditions. Author Anastasis Polycarpou provides the reader with all information necessary to successfully apply the finite element method to one- and two-dimensional boundary-value problems in electromagnetics.The book is accompanied by a number of codes written by the author in Matlab. These are the finite element codes that were used to generate most of the graphs presented in this book. Specifically, there are three Matlab codes for the one-dimensional case (Chapter 1) and two Matlab codes for the two-dimensional case (Chapter 2). The reader may execute these codes, modify certain parameters such as mesh size or object dimensions, and visualize the results. The codes are available on the Morgan & Claypool Web site at http://www.morganclaypool.com.
The Finite Difference Time Domain Method for Electromagnetics Electromagnetic Modeling by Finite Element Methods
The purpose of this book is to provide an up-to-date introduction to the time-domain finite element methods for Maxwell's equations involving metamaterials. Since the first successful construction of a metamaterial with both negative permittivity and permeability in 2000, the study of metamaterials has attracted significant attention from researchers across many disciplines. Thanks to enormous efforts on the part of engineers and physicists, metamaterials present great potential applications in antenna and radar design, sub-wavelength imaging, and invisibility cloak design. Hence the efficient simulation of electromagnetic phenomena in metamaterials has become a very important issue and is the subject of this book, in which various metamaterial modeling equations are introduced and justified mathematically. The development and practical implementation of edge finite element methods for metamaterial Maxwell's equations are the main focus of the book. The book finishes with some interesting simulations such as backward wave propagation and time-domain cloaking with metamaterials.
Electromagnetic Modeling by Finite Element Methods John Wiley & Sons
We present a parallel goal-oriented adaptive finite element algorithm that can be used to rapidly compute highly accurate solutions for 2.5D controlled-source electromagnetic (CSEM) and 2D magnetotelluric (MT) modeling problems. We employ unstructured triangular grids to permit efficient discretization of complex modeling domains such as those containing topography, dipping layers and multiple scale structures. Iterative mesh refinement is guided by a goal-oriented error estimator based on a form of dual residual weighting, which is carried out using hierarchical basis computations. Our formulation of the error estimator considers the relative error in the strike aligned fields and their spatial gradients, and therefore results in a more efficient use of mesh vertices than previous error estimators based on absolute field errors. This algorithm is parallelized over frequencies, transmitters, receivers and wave-numbers, where adaptive refinement can be performed in parallel on subsets of these parameters while nearby parameters are able to share the refined grid, thus enabling our algorithm to achieve accurate solutions in run-times of seconds to tens of seconds for realistic models and data parameters when run on cluster computers containing about a thousand processors. Application of this new algorithm to a complex model that includes strong seafloor topography variations and multiple thin stacked reservoirs demonstrates the performance and scalability on a large cluster computer.
Modeling and Computations in Electromagnetics John Wiley & Sons
Modeling of Resistivity and Acoustic Borehole Logging Measurements Using Finite Element Methods provides a comprehensive review of different resistivity and sonic logging instruments used within the oil industry, along with precise and solid mathematical descriptions of the physical equations and corresponding FE formulations that govern these measurements. Additionally, the book emphasizes the main modeling considerations that one needs to incorporate into the simulations in order to obtain reliable and accurate results. Essentially, the formulations and methods described here can also be applied to simulate on-surface geophysical measurements such as seismic or marine controlled-source electromagnetic (CSEM) measurements. Simulation results obtained using FE methods are superior. FE methods employ a mathematical terminology based on FE spaces that facilitate the design of sophisticated formulations and implementations according to the specifics of each problem. This mathematical FE framework provides a highly accurate, robust, and flexible unified environment for the solution of multi-physics problems. Thus, readers will benefit from this resource by learning how to make a variety of logging simulations using a unified FE framework. Provides a complete and unified finite element approach to perform borehole sonic and electromagnetic simulations Includes the latest research in mathematical and implementation content on Finite Element simulations of borehole logging measurements Features a variety of unique simulations and numerical examples that allow the reader to easily learn the main features and limitations that appear when simulating borehole resistivity measurements
Antennas, Microwave Circuits, and Scattering Applications Springer Science & Business Media
Seismoelectric coupling and its current and potential future applications The seismoelectric method—the naturally-occurring coupling of seismic waves to electromagnetic fields—can provide insight into important properties of porous media. With a variety of potential environmental and engineering uses, as well as larger scale applications such as earthquake detection and oil and gas exploration, it offers a number of advantages over conventional geophysical methods. Seismoelectric Exploration: Theory, Experiments, and Applications explores the coupling between poroelastic and electromagnetic disturbances, discussing laboratory experiments, numerical modeling techniques, recent theoretical developments, and field studies. Volume highlights include: Physics of the seismoelectric effect at the microscale Governing equations describing coupled seismo-electromagnetic fields Examples of successful seismoelectric field experiments in different geological settings Current and potential applications of seismoelectric coupling Noise removal techniques for seismoelectric field measurements The American Geophysical Union promotes discovery in Earth and space science for the benefit of humanity. Its publications disseminate scientific knowledge and provide resources for researchers, students, and professionals.
Finite Element Analysis of Antennas and Arrays Springer Nature
International Conference on Artificial Intelligence in Renewable Energetic Systems, IC-AIRES2019, 26-28 November 2019, Taghit-Bechar, Algeria. The challenges of the energy transition in the medium term lead to numerous technological breakthroughs in the areas of production, optimal distribution and the rational use of energy and renewable energy (energy efficiency and optimization of consumption, massive electrification, monitoring and control energy systems, cogeneration and energy recovery processes, new and renewable energies, etc.). The fall in the cost of renewable energies and the desire for a local control of energy production are today calling for a profound change in the electricity system. Local authorities are at the center of energy developments by taking into account the local nature of certain energy systems, heat networks, geothermal energy, waste heat recovery, and electricity generation from household waste. On the other side, digital sciences are at the heart of connected objects and intelligent products that combine information processing and communication capabilities with their environment. Digital technology is at the center of new systems engineering approaches (3D modeling, virtualization, simulation, digital prototyping, etc.) for the design and development of intelligent systems. The book deals with various topics ranging from the design, development and maintenance of energy production systems, transport, distribution or storage of energy, optimization of energy efficiency, especially in the use of energy. innovation in the fields of energy production from renewable energies, management of energy networks: electricity, fluids, gas, district heating, energy storage modes: battery, super-capacitors , overseeing energy supply through supervision, control and diagnosis, risk management, as well as the design and management of smart grids: microgrid, smartgrid. This imposes the model of energy empowerment in the advent of smart cities. Empower the world's most vulnerable energy-poor citizens and establish growing and vibrant socioeconomic communities, by academics, students in engineering and data computing from around the world who have chosen an academic path leading to an electric power and energy engineering and artificial intelligence to advancing technology for the advantage of humanity.
The Finite Element Method in Electromagnetics Springer Science & Business Media
Magnetic Materials and 3D Finite Element Modeling explores material characterization and finite element modeling (FEM) applications. This book relates to electromagnetic analysis based on Maxwell's equations and application of the finite element (FE) method to low frequency devices. A great source for senior undergraduate and graduate students in electromagnetics, it also supports industry professionals working in magnetics, electromagnetics, ferromagnetic materials science and electrical engineering. The authors present current concepts on ferromagnetic material characterizations and losses. They provide introductory material; highlight basic electromagnetics, present experimental and numerical modeling related to losses and focus on FEM applied to 3D applications. They also explain various formulations, and discuss numerical codes. • Furnishes algorithms in computational language • Summarizes concepts related to the FE method • Uses classical algebra to present the method, making it easily accessible to engineers Written in an easy-to-understand tutorial format, the text begins with a short presentation of Maxwell's equations, discusses the generation mechanism of iron losses, and introduces their static and dynamic components. It then demonstrates simplified models for the hysteresis phenomena under alternating magnetic fields. The book also focuses on the Preisach and Jiles–Atherton models, discusses vector hysterisis modeling, introduces the FE technique, and presents nodal and edge elements applied to 3D FE formulation connected to the hysteretic phenomena. The book discusses the concept of source-field for magnetostatic cases, magnetodynamic fields, eddy currents, and anisotropy. It also explores the need for more sophisticated coding, and presents techniques for solving linear systems generated by the FE cases while considering advantages and drawbacks.
Finite Element Methods for the Electromagnetic Modeling of Waveguide Discontinuities and Cavity Resonators Morgan & Claypool Publishers
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.
Electromagnetic Modeling and Simulation Open Dissertation Press
Increases in both the performance requirements of electronic devices and the number of components per device suggest that component size and configuration must be strongly considered in the design process. The layout and construction of device components are pertinent factors for consideration, and component interaction must be incorporated into any complete and accurate research investigation of electronic devices and packaging. In the current research, attention is focused on the electrical design of the devices and the corresponding electromagnetic field behavior within the individual components. In addition, consideration is given to effects due to materials and other parameters upon which circuit elements situated in very-large-scale-integrated (VLSI) circuits are dependent. A full-wave analysis is performed for a variety of configurations, with the finite element method (FEM) serving as a consistent and reliable technique for modeling field behavior within electronic circuit components. Several geometries are investigated. Problems which may be analyzed with two-dimensional techniques are considered. The coaxial waveguide and junction discontinuities are modeled, from which field patterns and scattering parameters for the device are determined. In this geometry, the transverse electromagnetic mode is dominant. Discussion and implementation of an absorbing boundary condition are also included. A nodal finite element approach is satisfactory in this case. Next, cylindrical geometries which exhibit azimuthal symmetry are studied, and a modified finite element

technique requiring both nodal and edge unknowns is utilized. Origins of spurious solutions frequently encountered in the study of circular resonant cavities are discussed, and a transformation of variables is presented to account for this difficulty. Finally, the general three-dimensional cavity and waveguide problems are investigated using an edge-element approach, as before, to eliminate any problems due to spurious solutions. Several resonant cavities and waveguide discontinuity problems are considered. An absorbing boundary condition is again discussed and implemented.

The Finite Element Method for Electromagnetic Modeling CRC Press

Useful in analyzing electromagnetic problems in a variety of engineering circumstances, the finite element method is a powerful simulation technique. This book explains the method's processes and techniques in careful, meticulous prose. It covers not only essential finite element method theory, but also its latest developments and applications. The Finite Element Method is an engineer's key to solving boundary-value problems.

Microwave Circuit Modeling Using Electromagnetic Field Simulation John Wiley & Sons

Unlike any other source in the field, this valuable reference clearly examines key aspects of the finite element method (FEM) for electromagnetic analysis of low-frequency electrical devices. The authors examine phenomena such as nonlinearity, mechanical force, electrical circuit coupling, vibration, heat, and movement for applications in the electrical, mechanical, nuclear, aeronautics, and transportation industries. Electromagnetic Modeling by Finite Element Methods offers a wide range of examples, including torque, vibration, and iron loss calculation; coupling of the FEM with mechanical equations, circuits, converters, and thermal effects; material modeling; and proven methods for hysteresis implementation into FEM codes. Providing experimental results and comparisons from the authors' personal research, Electromagnetic Modeling by Finite Element Methods supplies techniques to implement FEM for solving Maxwell's equations, analyze electrical and magnetic losses, determine the behavior of electrical machines, evaluate force distribution on a magnetic medium, simulate movement in electrical machines and electromagnetic devices fed by external circuits or static converters, and analyze the vibrational behavior of electrical machines.

Electromagnetic Modeling by Finite Element Methods Artech House Publishers

In this dissertation, robust, efficient, and fast finite-element-based electromagnetic modeling is considered for integrated and packaged electronic components and systems using enhanced formulations and algorithms. First, efficient and robust formulations and algorithms are presented for two-dimensional waveguide eigenmode analysis, which provides the foundation for the development of a waveguide-mode based port excitation model. This model is used in the multiple-input, multipleoutput finite element analysis of multiport electromagnetic devices and, in general, multiport electromagnetic systems. Next, a Krylov subspace model order reduction method is developed and demonstrated for broadband macromodeling of finite element approximations of electromagnetic devices and structures. Unique attributes of the method include its ability to handle frequency-dependent material properties as well as frequency-dependent surface impedance conditions. This model order reduction framework is further enhanced with new models for efficient handling of electrically small geometric features, such as thin wires. Such models, complemented by convenient schemes for the direct incorporation of lumped circuit elements in the finite element model of the electromagnetic structure, result in a comprehensive, finite element modeling framework for multiscale electromagnetic analysis. Finally, a model order reduction assisted domain decomposition methodology is proposed and demonstrated for the electromagnetic modeling of planar, multilayered electromagnetic circuits, of the type encountered in the signal and power distribution networks of high-speed digital and RF/microwave integrated electronic systems. Through its application to a series of case studies, the proposed methodology proves helpful in reducing modeling and numerical solution complexity, while providing for uncompromized electromagnetic accuracy.

Finite Elements, Electromagnetics and Design John Wiley & Sons

Over the past 10 years, both academia and industry collected large amounts of EM data. Compared with the abundance of data, the processing capacity is the bottleneck to have deeper insight into the earth. To increase the 3D processing capacity, this dissertation focuses on developing a 3D EM data processing toolkit, which could connect from data to model, uncovering the conductivity distribution of the seafloor. The first part of the dissertation employs a parallel goal-oriented adaptive finite element method for 3D electromagnetic modeling. To efficiently discretize the model, we use the unstructured tetrahedral mesh to accommodate arbitrarily complex 3D conductivity variations. Accuracy of the finite element solution could be achieved through adaptive mesh refinement that is performed iteratively until the solution converges to the desired accuracy tolerance. Refinement is guided by the goal-oriented error estimation approach to generate the optimal mesh, such that accurate EM responses at the locations of the EM receivers could be calculated. To further improve the computational efficiency, our algorithm is parallelized over frequencies, transmitters and receivers. We benchmark the newly developed algorithm by validating the controlled-source EM solutions on a 1D layered model. Furthermore, we employ a 3D model with significant seafloor bathymetry variations and a heterogeneous subsurface to demonstrate the code's ability to model complex features. In the second part, we introduce the framework for 3D inversion of marine controlled-source electromagnetic (CSEM) data. Our code, named Modeling with Adaptively Refined Elements for 3D EM (MARE3DEM), uses a new variant of the regularized Occam method for the inversion. The forward solver introduced previously serves as the backbone to calculate the model response and jacobians. The forward and inverse meshes are decoupled, such that we could accommodate the size of the inverse problem without sacrificing the accuracy of the forward solution. The sensitivity kernels which describe the change of the responses with respect to the variation of model parameters are efficiently calculated using the adjoint method. We show the reliability and the potential of the inversion algorithm by applying it to the inversion of synthetic marine controlled-source EM data.

The Finite Element Method in Electromagnetics John Wiley & Sons

As a slag heap, the result of strip mining, creeps closer to his house in the Ohio hills, fifteen-year-old M. C. is torn between trying to get his family away and fighting for the home they love.

A Volume Dedicated to Jean-Claude Nédélec Artech House

The first book applying HBFEM to practical electronic nonlinear field and circuit problems • Examines and solves wide aspects of practical electrical and electronic nonlinear field and circuit problems presented by HBFEM • Combines the latest research work with essential background knowledge, providing an all-encompassing reference for researchers, power engineers and students of applied electromagnetics analysis • There are very few books dealing with the solution of nonlinear electric- power-related problems • The contents are based on the authors’ many years’ research and industry experience; they approach the subject in a well-designed and logical way • It is expected that HBFEM will become a more useful and practical technique over the next 5 years due to the HVDC power system, renewable energy system and Smart Grid, HF magnetic used in DC/DC converter, and Multi-pulse transformer for HVDC power supply • HBFEM can provide effective and economic solutions to R&D product development • Includes Matlab exercises

Low-Frequency Electromagnetic Modeling for Electrical and Biological Systems Using MATLAB Butterworth-Heinemann

Designed for a one-semester course in Finite Element Method, this compact and well-organized text presents FEM as a tool to find approximate solutions to differential equations. This provides the student a better perspective on the technique and its wide range of applications. This approach reflects the current trend as the present-day applications range from structures to biomechanics to electromagnetics, unlike in conventional texts that view FEM primarily as an extension of matrix methods of structural analysis. After an introduction and a review of mathematical preliminaries, the book gives a detailed discussion on FEM as a technique for solving differential equations and variational formulation of FEM. This is followed by a lucid presentation of one-dimensional and two-dimensional finite elements and finite element formulation for dynamics. The book concludes with some case studies that focus on industrial problems and Appendices that include mini-project topics based on near-real-life problems. Postgraduate/Senior undergraduate students of civil, mechanical and aeronautical engineering will find this text extremely useful; it will also appeal to the practising engineers and the teaching community.

Frequency Domain Hybrid Finite Element Methods in Electromagnetics Elsevier

We have developed a mixed Vector Finite Element Method (VFEM) for Maxwell's equations with a nonlinear polarization term. The method allows for discretization of complicated geometries with arbitrary order representations of the B and E fields. In this paper we will describe the method and a series of optimizations that significantly reduce the computational cost. Additionally, a series of test simulations will be presented to validate the method. Finally, a nonlinear waveguide mode mixing example is presented and discussed.