



Electromagnetic Modeling By Finite Element Methods

Gregory Martiné Wilkins



Electromagnetic Modeling By Finite Element Methods:

Electromagnetic Modeling by Finite Element Methods João Pedro A. Bastos, Nelson Sadowski, 2003-04-01 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 elect Iterative and Self-adaptive Finite-elements in Electromagnetic Modeling Magdalena Salazar-Palma, 1998 Ensure the accuracy of your results when applying the Finite Element Method FEM to electromagnetic and antenna problems with this self contained reference It provides you with a solid understanding of the method describes its key elements and numerical techniques and identifies various approaches to using the FEM in solving real world microwave field problems **The Finite Element Method for Electromagnetic Modeling** Gérard Meunier, 2010-01-05 The Finite Element Method for Electromagnetic Modeling Written by specialists in the modeling of electromagnetism this book provides a comprehensive review of the finite element method for low frequency applications Fundamentals of the method as well as new advances in the field are described in detail Static magnetodynamic and fixed formulations are first covered before the discussion moves on to different macroscopic behavior laws of materials and their implementation in a finite element context and to more specific formulations the modeling of thin regions when finite elements become ill fitting the coupling of 2D and 3D formulations with circuit equations taking into account the presence of eddy currents and the treatment of geometric symmetries when the sources are not symmetric Coupled problems are then outlined before the book concludes with coverage of different meshing methods in the context of electromagnetism and optimization techniques **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

Multigrid Finite Element Methods for Electromagnetic Field Modeling Yu

Zhu, Andreas C. Cangellaris, 2006-02-17 This is the first comprehensive monograph that features state of the art multigrid methods for enhancing the modeling versatility numerical robustness and computational efficiency of one of the most popular classes of numerical electromagnetic field modeling methods the method of finite elements The focus of the publication is the development of robust preconditioners for the iterative solution of electromagnetic field boundary value problems BVPs discretized by means of finite methods Specifically the authors set forth their own successful attempts to utilize concepts from multigrid and multilevel methods for the effective preconditioning of matrices resulting from the approximation of electromagnetic BVPs using finite methods Following the authors careful explanations and step by step instruction readers can duplicate the authors results and take advantage of today s state of the art multigrid multilevel preconditioners for finite element based iterative electromagnetic field solvers Among the highlights of coverage are Application of multigrid multilevel and hybrid multigrid multilevel preconditioners to electromagnetic scattering and radiation problems Broadband robust numerical modeling of passive microwave components and circuits Robust finite element based modal analysis of electromagnetic waveguides and cavities Application of Krylov subspace based methodologies for reduced order macromodeling of electromagnetic devices and systems Finite element modeling of electromagnetic waves in periodic structures The authors provide more than thirty detailed algorithms alongside pseudo codes to assist readers with practical computer implementation In addition each chapter includes an applications section with helpful numerical examples that validate the authors methodologies and demonstrate their computational efficiency and robustness This groundbreaking book with its coverage of an exciting new enabling computer aided design technology is an essential reference for computer programmers designers and engineers as well as graduate students in engineering and applied physics

MATLAB-based Finite Element Programming in Electromagnetic Modeling Ozlem Ozgun, Mustafa Kuzuoglu, 2019

[The Finite Element Method in Electromagnetics](#) Jian-Ming Jin, 2014-03-31 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

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

Multigrid Finite Element Methods for Electromagnetic Field Modeling Yu Zhu, Andreas C. Cangellaris, 2006-02-03 This is the first comprehensive monograph that features state of the art multigrid methods for enhancing the modeling versatility numerical robustness and computational efficiency of one of the most popular classes of numerical electromagnetic field modeling methods the method of finite elements The focus of the publication is the development of robust preconditioners for the iterative solution of electromagnetic field boundary value problems BVPs discretized by means of finite methods Specifically the authors set forth their own successful attempts to utilize concepts from multigrid and multilevel methods for the effective preconditioning of matrices resulting from the approximation of electromagnetic BVPs using finite methods Following the authors careful explanations and step by step instruction readers

can duplicate the authors results and take advantage of today s state of the art multigrid multilevel preconditioners for finite element based iterative electromagnetic field solvers Among the highlights of coverage are Application of multigrid multilevel and hybrid multigrid multilevel preconditioners to electromagnetic scattering and radiation problems Broadband robust numerical modeling of passive microwave components and circuits Robust finite element based modal analysis of electromagnetic waveguides and cavities Application of Krylov subspace based methodologies for reduced order macromodeling of electromagnetic devices and systems Finite element modeling of electromagnetic waves in periodic structures The authors provide more than thirty detailed algorithms alongside pseudo codes to assist readers with practical computer implementation In addition each chapter includes an applications section with helpful numerical examples that validate the authors methodologies and demonstrate their computational efficiency and robustness This groundbreaking book with its coverage of an exciting new enabling computer aided design technology is an essential reference for computer programmers designers and engineers as well as graduate students in engineering and applied physics 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

Electromagnetics through the Finite Element Method José Roberto Cardoso, 2016-10-03 Shelving Guide Electrical Engineering Since the 1980s more than 100 books on the finite element method have been published making this numerical method the most popular The features of the finite element method gained worldwide popularity due to its flexibility for simulating not only any kind of physical phenomenon described by a set of differential equations but also for the possibility of simulating non linearity and time dependent studies Although a number of high quality books cover all subjects in engineering problems none of them seem to make this method simpler and easier to understand This book was written with the goal of simplifying the mathematics of the finite element method for electromagnetic students and professionals relying on the finite element method for solving design problems Filling a gap in existing literature that often uses complex mathematical formulas Electromagnetics through the Finite Element Method presents a new mathematical approach based on only direct integration of Maxwell s equation This book makes an original scholarly contribution to our current

understanding of this important numerical method 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 **Finite Element Method to Model Electromagnetic Systems in Low Frequency** Francis Piriou, Stephane Clenet, 2024-02-23 Numerical modeling now plays a central role in the design and study of electromagnetic systems In the field of devices operating in low frequency it is the finite element method that has come to the fore in recent decades Today it is widely used by engineers and researchers in industry as well as in research centers This book describes in detail all the steps required to discretize Maxwell's equations using the finite element method This involves progressing from the basic equations in the continuous domain to equations in the discrete domain that are solved by a computer This approach is carried out with a constant focus on maintaining a link between physics i.e. the properties of electromagnetic fields and numerical analysis Numerous academic examples which are used throughout the various stages of model construction help to clarify the developments

Finite Element Methods for the Electromagnetic Modeling of Waveguide Discontinuities and Cavity Resonators Gregory Martiné Wilkins, 1992 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

ADVD FINITE ELEMENT METHODOLOG Yanlin Li, 2017-01-26 This dissertation Advanced Finite Element Methodology for Low frequency and Static Electromagnetic Modeling by Yanlin Li was obtained from The University of Hong Kong Pokfulam Hong Kong and is being sold pursuant to Creative Commons Attribution 3.0 Hong Kong License The content of this dissertation has not been altered in any way We have altered the formatting in order to facilitate the ease of printing and reading of the dissertation All rights not granted by the above license are retained by the author Abstract The design of state of the art microelectronic devices poses unprecedented challenges to computational electromagnetics CEM which is cursed by the null space of curl operator Both the low frequency catastrophe for dynamic electromagnetic problems and non uniqueness for magnetostatic problems originate from the null space Although a few remedies are proposed during the last decade a theoretically rigorous and numerically efficient solution is still on its way Toward this end this thesis constructs a finite element framework which consists of generalized gauge condition compatible finite element discretization sparse approximate inverse SAI technique and static incomplete LU ILU preconditioned iterative solution The generalized gauge condition introduces a gauge operator which is comparable in magnitude and complementary in space with the double curl operator into the original governing equations The null space is removed and the combined operator becomes positive definite However the combined operator is so complicated that its discretization and matrix representation are unclear Thanks to the theory of differential forms the mapping of the quantity of interest from one form to another becomes distinct Hence the compatible discretization can be carried out based on the versatile Whitney elements The resultant matrix system is much better conditioned than that of the ungauged one whereas more treatment is still necessary to make it less sparse

and faster convergent The SAI and ILU preconditioning techniques provide an excellent solution to this difficulty The former approximates the inverse of a mass matrix by a nearly diagonal matrix which greatly reduces the sparsity of the matrix system The later shifts all the eigenvalues to the neighborhood of 1 and thus achieves an extremely fast convergence Moreover the static incomplete LU ILU preconditioning scheme is well suited to wideband analysis because the preconditioner is calculated just once for a wide range of frequency This framework is verified by low frequency circuit problems as well as magnetostatic ones to be accurate and efficient In addition more effort is devoted to explore other possibilities to solve the aforementioned problem The application of loop basis functions is also a promising solution provided that the redundant loops in the mesh can be removed Finally the displacement current effect is studied in depth by a full wave semianalytical solution of wireless power transfer into dispersive layered media The comparison between the results with and without the displacement current advocates the full wave electromagnetic modeling for multi scale problems and wideband analysis Subjects Finite element method Electromagnetism Computer simulation

Finite Element Analysis of Antennas and Arrays Jian-Ming Jin, Douglas J. Riley, 2009-02-23 The Most Complete Up to Date Coverage of the Finite Element Analysis and Modeling of Antennas and Arrays Aimed at researchers as well as practical engineers and packed with over 200 illustrations including twenty two color plates Finite Element Analysis of Antennas and Arrays presents Time and frequency domain formulations and mesh truncation techniques Antenna source modeling and parameter calculation Modeling of complex materials and fine geometrical details Analysis and modeling of narrowband and broadband antennas Analysis and modeling of infinite and finite phased array antennas Analysis and modeling of antenna and platform interactions Recognizing the strengths of other numerical methods this book goes beyond the finite element method and covers hybrid techniques that combine the finite element method with the finite difference time domain method the method of moments and the high frequency asymptotic methods to efficiently deal with a variety of complex antenna problems Complemented with numerous examples this cutting edge resource fully demonstrates the power and capabilities of the finite element analysis and its many practical applications

Advances in Modeling and Interpretation in Near Surface Geophysics Arkoprovo Biswas, Shashi Prakash Sharma, 2020-01-01 This book deals primarily with the aspects of advances in near surface geophysical data modeling different interpretation techniques new ideas and an integrated study to delineate the subsurface structures It also involves the practical application of different geophysical methods to delineate the subsurface structures associated with mineral groundwater exploration subsurface contamination hot springs coal fire etc This book is specifically aimed with the state of art information regarding research advances and new developments in these areas of study coupled to extensive modeling and field investigations obtained from around the world It is extremely enlightening for the research workers scientists faculty members and students in Applied Geophysics Near Surface Geophysics Potential Field Electrical and Electromagnetic Methods Mathematical Modeling Techniques in Earth Sciences as

well as Environmental Geophysics *Electromagnetic Modeling and Simulation* Levent Sevgi, 2014-03-13 This unique book presents simple easy to use but effective short codes as well as virtual tools that can be used by electrical electronic communication and computer engineers in a broad range of electrical engineering problems Electromagnetic modeling is essential to the design and modeling of antenna radar satellite medical imaging and other applications In this book author Levent Sevgi explains techniques for solving real time complex physical problems using MATLAB based short scripts and comprehensive virtual tools Unique in coverage and tutorial approach Electromagnetic Modeling and Simulation covers fundamental analytical and numerical models that are widely used in teaching research and engineering designs including mode and ray summation approaches with the canonical 2D nonpenetrable parallel plate waveguide as well as FDTD MoM and SSPE scripts The book also establishes an intelligent balance among the essentials of EM MODSIM The Problem the physics The Theory and Models mathematical background and analytical solutions and The Simulations code developing plus validation verification and calibration Classroom tested in graduate level and short courses Electromagnetic Modeling and Simulation Clarifies concepts through numerous worked problems and quizzes provided throughout the book Features valuable MATLAB based user friendly effective engineering and research virtual design tools Includes sample scenarios and video clips recorded during characteristic simulations that visually impact learning available on wiley com Provides readers with their first steps in EM MODSIM as well as tools for medium and high level code developers and users Electromagnetic Modeling and Simulation thoroughly covers the physics mathematical background analytical solutions and code development of electromagnetic modeling making it an ideal resource for electrical engineers and researchers **Circuit Oriented Electromagnetic Modeling Using the PEEC Techniques** Albert Ruehli, Giulio Antonini, Lijun Jiang, 2017-06-19 Bridges the gap between electromagnetics and circuits by addressing electrometric modeling EM using the Partial Element Equivalent Circuit PEEC method This book provides intuitive solutions to electromagnetic problems by using the Partial Element Equivalent Circuit PEEC method This book begins with an introduction to circuit analysis techniques laws and frequency and time domain analyses The authors also treat Maxwell s equations capacitance computations and inductance computations through the lens of the PEEC method Next readers learn to build PEEC models in various forms equivalent circuit models non orthogonal PEEC models skin effect models PEEC models for dielectrics incident and radiate field models and scattering PEEC models The book concludes by considering issues like stability and passivity and includes five appendices some with formulas for partial elements Leads readers to the solution of a multitude of practical problems in the areas of signal and power integrity and electromagnetic interference Contains fundamentals applications and examples of the PEEC method Includes detailed mathematical derivations Circuit Oriented Electromagnetic Modeling Using the PEEC Techniques is a reference for students researchers and developers who work on the physical layer modeling of IC interconnects and Packaging PCBs and high speed links **Multiphysics Simulation** Ercan M. Dede, Jaewook Lee, Tsuyoshi

Nomura,2014-05-28 This book highlights a unique combination of numerical tools and strategies for handling the challenges of multiphysics simulation with a specific focus on electromechanical systems as the target application Features introduces the concept of design via simulation along with the role of multiphysics simulation in today s engineering environment discusses the importance of structural optimization techniques in the design and development of electromechanical systems provides an overview of the physics commonly involved with electromechanical systems for applications such as electronics magnetic components RF components actuators and motors reviews the governing equations for the simulation of related multiphysics problems outlines relevant topology and parametric size optimization methods for electromechanical systems describes in detail several multiphysics simulation and optimization example studies in both two and three dimensions with sample numerical code

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