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 attempt to utilize concepts from multigrid and multilevel methods for 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...
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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 application 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.

The essential textbook for electrical engineering students and professionals—now in a valuable new edition—The increasing use of high-speed digital technology requires that all electrical engineers have a working knowledge of transmission lines. However, because of the introduction of computer engineering courses into already crowded four-year undergraduate programs, the transmission line courses in many electrical engineering programs have been relegated to a senior technical elective, if offered at all. Now, Analysis of Multiconductor Transmission Lines, Second Edition has been significantly updated and reorganized to fill the need for a structured course on transmission lines in a senior undergraduate- or graduate-level electrical engineering program. In this new edition, each broad analysis topic, e.g., per-unit-length parameters, frequency-domain analysis, time-domain analysis, and incident field excitation, now has a chapter concerning two-conductor lines followed immediately by a chapter on MTLs for that topic. This enables instructors to emphasize two-conductor lines or MTLs or both. In addition to the reorganization of the material, this Second Edition now contains important advancements in analysis methods that have developed since the previous edition, such as methods for achieving signal integrity (SI) in high-speed digital interconnects, the finite-difference, time-domain (FDTD) solution methods, and the time-domain to frequency-domain transformation (TDFD) method. Furthermore, the content of Chapters 8 and 9 on digital signal propagation and signal integrity application has been considerably expanded upon to reflect all of the vital information current and future designers of high-speed digital systems need to know. Complete with an accompanying FTP site, appendices with descriptions of numerous FORTRAN computer codes that implement all the techniques in the text, and a brief but thorough tutorial on the SPICE/PSPICE circuit analysis program, Analysis of Multiconductor Transmission Lines, Second Edition is an indispensable textbook for students and a valuable resource for industry professionals.

This monograph deals with the theoretical aspects of the circuit modelling of high-frequency electromagnetic structures using the Lorentz reciprocity theorem. This is the first book to cover the generalization from closed structures to open-boundary waveguides and circuit structures. The author has developed a new way to represent a general waveguide by transmission lines: and was awarded the Microwave Prize of the IEEE for this work. The first part of the book discusses the construction of transmission line models for waveguide structures. Then the incidence of external electromagnetic waves on high-frequency structures is studied, and finally the concepts derived in the earlier parts of the book are generalized to reciprocal and non-reciprocal anisotropic, bi-isotropic, and bianisotropic materials.

Four digital computer programs, XTALK, XTALK2, FLATPAK, FLATPAK2, for determining the electromagnetic coupling within an (n+1) conductor,
uniform transmission line are presented. Sinusoidal steady state behavior of the line as well as the TEM or ‘quasi-TEM’ mode of propagation are assumed. XTALK and XTALK2 consider lines consisting of n wires (cylindrical conductors) and a reference conductor. The surrounding medium is homogeneous and lossless. XTALK assumes that all (n+1) conductors are perfect conductors whereas XTALK2 considers the conductors to be lossy. There are three choices for the reference conductor: a wire, a ground plane, an overall cylindrical shield. FLATPAK and FLATPAK2 consider (n+1) wire ribbon (flatpack) cables in which all wires are identical and are coated with cylindrical, dielectric insulations of identical thicknesses. All wires lie in a horizontal plane and all adjacent wires are separated by identical distances. FLATPAK considers the wires to be perfect conductors and FLATPAK2 considers the wires to be lossy. The dielectric insulations are considered to be lossless. General termination networks are provided for at the ends of the line and the programs compute the voltages (with respect to the reference conductor) at the terminals of these termination networks for sinusoidal steady state excitation of the line.

Modeling and Simulation of High Speed VLSI Interconnects brings together in one place important contributions and state-of-the-art research results in this rapidly advancing area. Modeling and Simulation of High Speed VLSI Interconnects serves as an excellent reference, providing insight into some of the most important issues in the field.

This "know-how" book gives readers a concise understanding of the fundamentals of EMC, from basic mathematical and physical concepts through present, computer-age methods used in analysis, design, and tests. With contributions from leading experts in their fields, the text provides a comprehensive overview. Fortified with information on how to solve potential electromagnetic interference (EMI) problems that may arise in electronic design, practitioners will be better able to grasp the latest techniques, trends, and applications of this increasingly important engineering discipline. Handbook of Electromagnetic Compatibility contains extensive treatment of EMC applications to radio and wireless communications, fiber optics communications, and plasma effects. Coverage of EMC-related issues includes lightning, electromagnetic pulse, biological effects, and electrostatic discharge. Practical examples are used to illustrate the material, and all information is presented in an accessible and organized format. The text is intended primarily for those practicing engineers who need a good foundation in EMC, but it will also interest faculty and students, since a good portion of the material covered can find use in the classroom or as a springboard for further research. The chapters are written by experts in the field.

This volume documents the research carried out by visiting scientists attached to the Institute for Mathematical Sciences (IMS) at the National University of Singapore and the Institute of High Performance Computing (IHPC) under the program “Advances and Mathematical Issues in Large Scale Simulation.” From 2002 to 2003, researchers from various countries gathered to initiate interesting and innovative work on various themes related to multiscale simulation and fast algorithms. Today, modeling and simulation are used extensively to solve complex problems and to reduce the use of experimentation during the design and analysis stage. It is important to know the various issues that have to be considered in the successful development of computational methodologies for such work. This volume is a compilation of the research by various visiting scientists in the area of modeling and multiscale simulation.
Each article covers a major project and documents how computational methodology, mathematical modeling, high performance computing and simulation are combined in a multiscale scheme to solve a variety of complex problems. Some of these include the design, synthesis, processing, characterization and manufacture of nanomaterials and nanostructures, new algorithms for computational work, and grid computing. Through the included examples, readers can realize the vast potential of computational modeling and large scale simulation for the solution of problems in a variety of disciplines and applications. Contents:Methods of Multiscale Modeling in Mechanics (W A Curtin)Efficient and Accurate Boundary Methods for Computational Optics (C Hafner & J Smajic)Finite Element Modeling of Periodic Structures (Z Lou & J-M Jin)Factorization of Potential and Field Distributions without Utilizing the Addition Theorem (A-R Baghi-Wadji & E Li)Virtualization-Aware Application Framework for Hierarchical Multiscale Simulations on a Grid (A Nakano et al.)Molecular Dynamics Simulation and Local Quantities (T Ikeshoji)Recent Advances in Modeling and Simulation of High-Speed Interconnects (M Nakhla & R Achar)Multiscale Modeling of Degradation and Failure of Interconnect Lines Driven by Electromigration and Stress Gradients (R Atkinson & A M Cuitiño)Readership: Engineers, scientists and graduate students who need further insights into the applications and power of computational methodology for the solution of a wide array of problems. Keywords: Large Scale Simulation; High Performance Computing; Multiscale Simulation; Fast Algorithms; Computational MethodologyKey Features: Provides insight into the applications and power of computational methodology in solving a wide array of complex problems

This dissertation comprises the following four components. (1) Development of a robust and efficient 3-D finite element electromagnetic field solver with high-order vector elements for high-frequency and high-speed circuit simulations. The solver supports wave port and lumped port excitations as well as the incorporation of lumped networks and circuit models in a distributed finite element model. An adaptive multipoint model order reduction method is developed for fast broadband analysis. (2) Development of a fast and accurate multiconductor transmission line simulator and parameter extractor with improved model order reduction techniques. A methodology is further proposed for a combined quasi-TEM and full-wave transmission line analysis, which possesses their respective advantages and ensures full-wave accuracy from DC to very high frequencies. The transmission line analysis also takes into account the frequency dependence of dielectric materials. (3) Study of the low-frequency instability problem in the 3-D full-wave finite element simulation. The tree-cotree splitting is combined with several other techniques to improve the matrix conditioning and extend full-wave solutions down to very low frequencies for a more robust broadband characterization of high-speed digital circuits. (4) A combined domain decomposition model order reduction (DDOMOR) method for efficient full-wave analysis of interconnections in multilayer printed circuit boards. The method not only brings a significant enhancement to computational efficiency while maintaining full-wave accuracy, but also provides great flexibility in the finite element mesh generation.

* The first book on the subject. * Written by an acknowledged expert in the field. * The techniques discussed have important applications to wireless engineering.
This report describes the algorithms and numerical results for a lossless multiconductor transmission-line network which is excited by a number of lumped voltage and current sources located on the transmission lines. As opposed to previous analyses of multiconductor transmission lines, the method described in this report is capable of treating networks which contain one or more closed transmission-line loops. The formulation of this analysis involves defining a large matrix equation (the BLT equation for currents incident on each of the junctions of the transmission-line network. Matrix inversion then provides the solution for these incident currents, with the reflected current component then being determined from knowledge of the scattering properties of the junctions. The total junction currents are then found by combining the incident and reflected components. To illustrate this approach, a single-wire network and a more general multi-conductor transmission-line network are considered with numerical results for the voltages at points within the networks displayed. (Author).

In the last 30 years there have been dramatic changes in electrical technology--yet the length of the undergraduate curriculum has remained four years. Until some ten years ago, the analysis of transmission lines was a standard topic in the EE and CpE undergraduate curricula. Today most of the undergraduate curricula contain a rather brief study of the analysis of transmission lines in a one-semester junior-level course on electromagnetics. In some schools, this study of transmission lines is relegated to a senior technical elective or has disappeared from the curriculum altogether. This raises a serious problem in the preparation of EE and CpE undergraduates to be competent in the modern industrial world. For the reasons mentioned above, today's undergraduates lack the basic skills to design high-speed digital and high-frequency analog systems. It does little good to write sophisticated software if the hardware is unable to process the instructions. This problem will increase as the speeds and frequencies of these systems continue to increase seemingly without bound. This book is meant to repair that basic deficiency.

Using the frequency-dependent transmission line parameters, two time-domain models are developed for lossy multiconductor transmissions lines. It is shown that the endpoints of a lossy multiconductor line can be represented at each time step by discretized Thevenin or Norton equivalent circuits. Because these models contain only lumped elements, they can be easily implemented in a general circuit analysis program for simulating the transient responses of nonlinear circuits. The analysis procedure developed makes exclusive use of infinite-line impulse responses in the formulation of the time-domain models. Because infinite lines are matched, there are no reflections in the impulse responses. The result is that these impulse responses are relatively short. A number of simulation examples are presented exercising the lossy multiconductor transmission line model in circuits that contain linear and nonlinear elements. Of particular interest is the interconnection of high-speed digital circuits by lossy multiconductor transmission lines containing discontinuities. Results are shown for the most general case of lossy multiconductor transmission lines with discontinuities and nonlinear terminations in which the modal transformation matrices are necessarily frequency dependent. In addition, simulation results show good agreement with experimental results for both lossless and lossy multiconductor transmission lines.

Provides a comprehensive discussion of planar transmission lines and their applications, focusing on physical understanding, analytical approach, and circuit models Planar transmission lines form the core of the modern high-frequency communication, computer, and other related technology. This advanced text gives a complete overview of the technology and acts as a comprehensive tool for radio frequency (RF) engineers that reflects a linear discussion of the subject from fundamentals to more complex arguments. Introduction to Modern Planar Transmission Lines: Physical, Analytical, and Circuit Models
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Approach begins with a discussion of waves on transmission lines and waves in material medium, including a large number of illustrative examples from published results. After explaining the electrical properties of dielectric media, the book moves on to the details of various transmission lines including waveguide, microstrip line, co-planar waveguide, strip line, slot line, and coupled transmission lines. A number of special and advanced topics are discussed in later chapters, such as fabrication of planar transmission lines, static variational methods for planar transmission lines, multilayer planar transmission lines, spectral domain analysis, resonators, periodic lines and surfaces, and metamaterial realization and circuit models. Emphasizes modeling using physical concepts, circuit-models, closed-form expressions, and full derivation of a large number of expressions Explains advanced mathematical treatment, such as the variation method, conformal mapping method, and SDA Connects each section of the text with forward and backward cross-referencing to aid in personalized self-study Introduction to Modern Planar Transmission Lines is an ideal book for senior undergraduate and graduate students of the subject. It will also appeal to new researchers with the inter-disciplinary background, as well as to engineers and professionals in industries utilizing RF/microwave technologies.

This text discusses electromagnetics from the view of operator theory, in a manner more commonly seen in textbooks of quantum mechanics. It includes a self-contained introduction to operator theory, presenting definitions and theorems, plus proofs of the theorems when these are simple or enlightening.

The new and original material in this book will appeal to a diversified audience. R&D microwave scientists will appreciate the use of a perturbation approach to modal analysis and generalized modal theory. Owing to its rigorous treatment of both theoretical issues and practical applications, it is sure to become an indispensable handbook for engineers concerned with the design and modelling of microwave circuits, telecommunications systems, or power systems.

The essential textbook for electrical engineering students and professionals-now in a valuable new edition The increasing use of high-speed digital technology requires that all electrical engineers have a working knowledge of transmission lines. However, because of the introduction of computer engineering courses into already-crowded four-year undergraduate programs, the transmission line courses in many electrical engineering programs have been relegated to a senior technical elective, if offered at all. Now, Analysis of Multiconductor Transmission Lines, Second Edition has been significantly updated and reorganized to fill the need for a structured course on transmission lines in a senior undergraduate- or graduate-level electrical engineering program. In this new edition, each broad analysis topic, e.g., per-unit-length parameters, frequency-domain analysis, time-domain analysis, and incident field excitation, now has a chapter concerning two-conductor lines followed immediately by a chapter on MTLs for that topic. This enables instructors to emphasize two-conductor lines or MTLs or both. In addition to the reorganization of the material, this Second Edition now contains important advancements in analysis methods that have developed since the previous edition, such as methods for achieving signal integrity (SI) in high-speed digital interconnects, the finite-difference, time-domain (FDTD) solution methods, and the time-domain to frequency-domain transformation (TDFD) method. Furthermore, the content of Chapters 8 and 9 on digital signal propagation and signal integrity application has been considerably expanded upon to reflect all of the vital
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information current and future designers of high-speed digital systems need to know. Complete with an accompanying FTP site, appendices with descriptions of numerous FORTRAN computer codes that implement all the techniques in the text, and a brief but thorough tutorial on the SPICE/PSPICE circuit analysis program, Analysis of Multiconductor Transmission Lines, Second Edition is an indispensable textbook for students and a valuable resource for industry professionals.

This version of LINPAR for Windows is now compatible with Windows 95 and later. The software runs at four times the speed of the previous version, allowing the user to analyze arbitrary planar transmission lines in multilayered dielectrics, including microstrip lines, coupled suspended lines, coupled striplines, and coplanar waveguides; and any user-defined structure, such as flat cables and multi-wire shielded cables. The software can be used for precise analysis and design of microwave circuits, such as directional couplers, baluns, and coupled-line filters, and of fast digital-signal interconnects, including printed circuit buses and computer cables. There is an accompanying user manual.

The material presented in the report is intended to furnish a unified approach to understanding (1) the physical behavior of multiwire transmission lines as used in the realization of high-frequency electrical filters and couplers, and (2) the response of open-wire lines and of shielded cables to end excitation or to continuous excitation along the line by external electromagnetic fields. Scope of development is restricted entirely to monochromatic behavior of linear time-invariant systems, since, from that base, the response of the line to transient applied forces is readily synthesized by means of the Fourier theorem. The theory of lossless lines in homogeneous, isotropic dielectrics is applied in the derivation of basic line parameters of simple transmission line models. These parameters are related to the classical Maxwell capacitance coefficients. A number of practical configurations are discussed on which the designs of directional couplers, inductive and capacitive couplers, and wave filters, are based.

The evaluation of electromagnetic field coupling to transmission lines is an important problem in electromagnetic compatibility. Traditionally, use is made of the TL approximation which applies to uniform transmission lines with electrically small cross-sectional dimensions, where the dominant mode of propagation is TEM. Antenna-mode currents and higher-order modes appearing at higher frequencies are neglected in TL theory. The use of the TL approximation has permitted to solve a large range of problems (e.g. lightning and EMP interaction with power lines). However, the continual increase in operating frequency of products and higher frequency sources of disturbances (such as UWB systems) makes that the TL basic assumptions are no longer acceptable for a certain number of applications. In the last decade or so, the generalization of classical TL theory to take into account high frequency effects has emerged as an important topic of study in electromagnetic compatibility. This effort resulted in the elaboration of the so-called ‘generalized’ or ‘full-wave’ TL theory, which incorporates high frequency radiation effects, while keeping the relative simplicity of TL equations. This book is organized in two main parts. Part I presents consolidated knowledge of classical transmission line theory and different field-to-transmission line coupling models. Part II presents different approaches developed to generalize TL Theory.
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Serving as a complete replacement for its predecessor stand-alone programs, LINRES and MATPAR, and as an extension of LINPAR for Windows, this work is used to create models for quick accurate analysis of circuits containing multiconductor transmission lines.

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.

This proceedings set contains selected Computer, Information and Education Technology related papers from the 2014 International Conference on Computer, Intelligent Computing and Education Technology (CICET 2014), held March 27-28, 2014 in Hong Kong. The proceedings aims to provide a platform for researchers, engineers and academics as well as indu

The matrix formulation of the transmission line equations was applied in a semi-empirical manner to predict electromagnetic coupling with multiconductor transmission lines. Experimental procedures were used for measuring characteristic electrical parameters for transmission lines. The NLINE multiconductor transmission line computer program was used with experimental data for analysis of transmission-line samples made up of 2, 3, and 11 conductors. Parametric variations in angle of incidence and transmission line parameters were studied and compared with experimental results. The validity of simplifying approximations was checked with experimental data.

The theory of transmission lines is a classical topic of electrical engineering. Recently this topic has received renewed attention and has been a focus of considerable research. This is because the transmission line theory has found new and important applications in the area of high-speed VLSI interconnects, while it has retained its significance in the area of power transmission. In many applications, transmission lines are connected to nonlinear circuits. For instance, interconnects of high-speed VLSI chips can be modeled as transmission lines loaded with nonlinear elements. These nonlinearities may lead to many new effects such as instability, chaos, generation of higher order harmonics, etc. The mathematical models of transmission lines with nonlinear loads consist of the linear partial differential equations describing the current and voltage dynamics along the lines together with the nonlinear boundary conditions imposed by the nonlinear loads connected to the lines. These nonlinear boundary conditions make the mathematical treatment very difficult. For
this reason, the analysis of transmission lines with nonlinear loads has not been addressed adequately in the existing literature. The unique and distinct feature of the proposed book is that it will present systematic, comprehensive, and in-depth analysis of transmission lines with nonlinear loads. A unified approach for the analysis of networks composed of distributed and lumped circuits A simple, concise and completely general way to present the wave propagation on transmission lines, including a thorough study of the line equations in characteristic form Frequency and time domain multiport representations of any linear transmission line A detailed analysis of the influence on the line characterization of the frequency and space dependence of the line parameters A rigorous study of the properties of the analytical and numerical solutions of the network equations The associated discrete circuits and the associated resistive circuits of transmission lines Periodic solutions, bifurcations and chaos in transmission lines connected to nonlinear lumped circuits