

George W. Hanson / Alexander B. Yakovlev

# Operator Theory for Electromagnetics

**An Introduction**



Springer

# Operator Theory For Electromagnetics An Introduction

**Akhlesh Lakhtakia, Cynthia M. Furse**



## **Operator Theory For Electromagnetics An Introduction:**

**Operator Theory for Electromagnetics** George W. Hanson,Alexander B. Yakovlev,2013-03-09 The purpose of this book is to describe methods for solving problems in applied electromagnetic theory using basic concepts from functional analysis and the theory of operators Although the book focuses on certain mathematical fundamentals it is written from an applications perspective for engineers and applied scientists working in this area Part I is intended to be a somewhat self contained introduction to operator theory and functional analysis especially those elements necessary for application to problems in electromagnetics The goal of Part I is to explain and synthesize these topics in a logical manner Examples principally geared toward electromagnetics are provided With the exception of Chapter 1 which serves as a review of basic electromagnetic theory Part I presents definitions and theorems along with associated discussion and examples This style was chosen because it allows one to readily identify the main concepts in a particular section A proof is provided for all theorems whose proof is simple and straightforward A proof is also provided for theorems that require a slightly more elaborate proof yet one that is especially enlightening being either constructive or illustrative Generally theorems are stated but not proved in cases where either the proof is too involved or the details of the proof would take one too far afield of the topic at hand such as requiring additional lemmas that are not clearly useful in applications

**Operator Theory for Electromagnetics: An Introduction** , *Operator Theory for Electromagnetics* George W. Hanson,Alexander B. Yakovlev,2001-10-12 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

*Integral Equation Methods for Electromagnetic and Elastic Waves* Weng Chew,Mei-Song Tong,Bin HU,2022-05-31 *Integral Equation Methods for Electromagnetic and Elastic Waves* is an outgrowth of several years of work There have been no recent books on integral equation methods There are books written on integral equations but either they have been around for a while or they were written by mathematicians Much of the knowledge in integral equation methods still resides in journal papers With this book important relevant knowledge for integral equations are consolidated in one place and researchers need only read the pertinent chapters in this book to gain important knowledge needed for integral equation research Also learning the fundamentals of linear elastic wave theory does not require a quantum leap for electromagnetic practitioners Integral equation methods have been around for several decades and their introduction to electromagnetics has been due to the seminal works of Richmond and Harrington in the 1960s There was a surge in the interest in this topic in the 1980s notably the work of Wilton and his coworkers due to increased computing power The interest in this area was on the wane when it was demonstrated that differential equation methods with their sparse matrices can solve many problems more efficiently than integral equation methods Recently due to the advent of fast algorithms there has been a revival in integral equation

methods in electromagnetics Much of our work in recent years has been in fast algorithms for integral equations which prompted our interest in integral equation methods While previously only tens of thousands of unknowns could be solved by integral equation methods now tens of millions of unknowns can be solved with fast algorithms This has prompted new enthusiasm in integral equation methods Table of Contents Introduction to Computational Electromagnetics Linear Vector Space Reciprocity and Energy Conservation Introduction to Integral Equations Integral Equations for Penetrable Objects Low Frequency Problems in Integral Equations Dyadic Green's Function for Layered Media and Integral Equations Fast Inhomogeneous Plane Wave Algorithm for Layered Media Electromagnetic Wave versus Elastic Wave Glossary of Acronyms

**Theory and Phenomena of Metamaterials** Filippo Capolino, 2017-12-19 Theory and Phenomena of Metamaterials offers an in depth look at the theoretical background and basic properties of electromagnetic artificial materials often called metamaterials A volume in the Metamaterials Handbook this book provides a comprehensive guide to working with metamaterials using topics presented in a concise review format along with numerous references With contributions from leading researchers this text covers all areas where artificial materials have been developed Each chapter in the text features a concluding summary as well as various cross references to address a wide range of disciplines in a single volume

*Optical Waveguide Theory* Yury Shestopalov, Yury Smirnov, Eugene Smolkin, 2022-03-26 This book addresses the most advanced to date mathematical approach and numerical methods in electromagnetic field theory and wave propagation It presents the application of developed methods and techniques to the analysis of waves in various guiding structures shielded and open metal dielectric waveguides of arbitrary cross section planar and circular waveguides filled with inhomogeneous dielectrics metamaterials chiral media anisotropic media and layered media with absorption It also looks into spectral properties of wave propagation for the waveguide families being considered and the relevant mathematical techniques such as spectral theory of non self adjoint operator valued functions are described including rigorous proofs of the existence of various types of waves Further numerical methods constructed on the basis of the presented mathematical approach and the results of numerical modeling for various structures are also described in depth The book is beneficial to a broad spectrum of readers ranging from pure and applied mathematicians in electromagnetic field theory to researchers and engineers who are familiar with mathematics Further it is also useful as a supplementary text for upper level undergraduate students interested in learning more advanced topics of mathematical methods in electromagnetics

**Ultrawideband Phased Array Antenna Technology for Sensing and Communications Systems** Alan J. Fenn, Peter T. Hurst, 2015-04-10 Practical ultrawideband phased array technology used in airborne and ground based systems applications Ultrawideband phased array antennas are an enabling technology for many ground based and airborne communications and radar systems This book surveys electromagnetic theory and phased array antenna theory and provides examples of ultrawideband phased array antenna technology It describes some of the research on ultrawideband phased arrays undertaken by the authors and their colleagues

at MIT Lincoln Laboratory over the last ten years The book focuses on experimental prototype ultrawideband phased array technology developed at Lincoln Laboratory for applications in the VHF and UHF bands from approximately 100 MHz to 1 GHz and addresses dipole monopole loop and other antenna array elements It offers examples of antennas for both airborne and ground vehicle applications Most of the examples are developed in the context of rapid prototyping for quick assessment of communications and radar systems feasibility with measurements and numerical electromagnetic simulation results provided for many prototype examples The book is intended primarily for practicing antenna engineers radar engineers and communications engineers and for graduate students and researchers in electrical engineering Readers need no prior knowledge of ultrawideband antennas although some background in electromagnetic theory antennas radar and communications would be helpful The World of Applied Electromagnetics Akhlesh Lakhtakia, Cynthia M.

Furse, 2017-08-08 This book commemorates four decades of research by Professor Magdy F Iskander Life Fellow IEEE on materials and devices for the radiation propagation scattering and applications of electromagnetic waves chiefly in the MHz THz frequency range as well on electromagnetics education This synopsis of applied electromagnetics stemming from the life and times of just one person is meant to inspire junior researchers and reinvigorate mid level researchers in the electromagnetics community The authors of this book are internationally known researchers including 14 IEEE fellows who highlight interesting research and new directions in theoretical experimental and applied electromagnetics Foundations of Applied Electrodynamics Wen Geyi, 2011-07-05 Foundations of Applied Electrodynamics takes a fresh look at the essential concepts and methods of electrodynamics as a whole uniting the most relevant contemporary topics under a common mathematical framework It contains clear explanations of high level concepts as well as the mutual relationships between the essential ideas of electromagnetic theory Starting with the fundamentals of electrodynamics it methodically covers a wide spectrum of research and applications that stem from electromagnetic phenomena before concluding with more advanced topics such as quantum mechanics Includes new advances and methodologies in applied electrodynamics and provides the whole picture of the theory of electrodynamics in most active areas of engineering applications Systematically deals with eigenvalue problems integral equation formulations and transient phenomena in various areas of applied electrodynamics Introduces the complete theory of spherical vector wave functions and presents the upper bounds of the product of gain and bandwidth for an arbitrary antenna Presents the field approach to multiple antenna system which provides a theoretical tool for the prediction of channel models of MIMO and is also the basis of wireless power transmission system One of the first books on electromagnetics that contains the general theory of relativity which is needed in the design of mobile systems such as global positioning system GPS By summarising both engineering and theoretical electromagnetism in one volume this book is an essential reference for practicing engineers as well as a guide for those who wish to advance their analytical techniques for studying applied electrodynamics **A Glimpse Beyond 5G in Wireless Networks** Mohammad Abdul

Matin,2022-11-30 This book gathers the latest research findings on emerging trends in 5G and beyond wireless systems The authors present and assess different enabling technologies capabilities and anticipated communications and computing solutions for 5G and beyond Topics discussed include new frequency bands new multiple antenna systems massive D2D connectivity new network deployment and more These discussions help the readers to understand more advanced research materials for developing new ideas to make a contribution in this field for themselves This book aims to serve as a virtual and effective bridge between academic research in theory and engineering development in practice Students professional and practitioners who seek to learn the latest development in wireless technologies should find interest in this book

Mathematics For Physicists Huaiyu Wang,2017-03-02 This book covers the necessary aspects of mathematics for graduate students in physics and engineering Advanced undergraduate students and researchers who intend to enter the field of theoretical physics can also pick up this book The first eight chapters include variational method Hilbert space and operators ordinary linear differential equations Bessel functions Dirac delta function the Green s function in mathematical physics norm integral equations Beside these traditional contents the last two chapters introduce some recent achievements of scientific research while presenting their mathematical background Like the basis of number theory and its application in physics material science and other scientific fields the fundamental equations in spaces with arbitrary dimensions not limited to Euclid space Pseudo spherical coordinates Plain terminologies were used to present the concept of metric as well as new and interesting work on the Klein Gordon equation and Maxwell equation     *Foundations For Radio Frequency Engineering*

Geyi Wen,2015-03-13 The book provides a comprehensive coverage of the fundamental topics in microwave engineering antennas and wave propagation and electromagnetic compatibility including electromagnetic boundary value problems waveguide theory microwave resonators antennas and wave propagation microwave circuits principles of electromagnetic compatibility designs information theory and systems Deals systematically with fundamental problems in radio frequency engineering this important volume provides an updated treatment of radio frequency theory and techniques The book can be used as a one semester course for senior and first year graduate students or as a reference for radio frequency engineers and applied physicists     **Cognitive Networked Sensing and Big Data** Robert Qiu,Michael Wicks,2013-08-04 Wireless

Distributed Computing and Cognitive Sensing defines high dimensional data processing in the context of wireless distributed computing and cognitive sensing This book presents the challenges that are unique to this area such as synchronization caused by the high mobility of the nodes The author will discuss the integration of software defined radio implementation and testbed development The book will also bridge new research results and contextual reviews Also the author provides an examination of large cognitive radio network hardware testbed distributed sensing and distributed computing

**Nanoplasmonics** Grégory Barbillon,2017-06-21 Nanoplasmonics is a young topic of research which is part of nanophotonics and nano optics Nanoplasmonics concerns to the investigation of electron oscillations in metallic

nanostructures and nanoparticles Surface plasmons have optical properties which are very interesting For instance surface plasmons have the unique capacity to confine light at the nanoscale Moreover surface plasmons are very sensitive to the surrounding medium and the properties of the materials on which they propagate In addition to the above the surface plasmon resonances can be controlled by adjusting the size shape periodicity and materials nature All these optical properties can enable a great number of applications such as biosensors optical modulators photodetectors and photovoltaic devices This book is intended for a broad audience and provides an overview of some of the fundamental knowledges and applications of nanoplasmonics

**Maxwell's Equations** Ulrich Langer,Dirk Pauly,Sergey Repin,2019-07-08 This volume collects longer articles on the analysis and numerics of Maxwell s equations The topics include functional analytic and Hilbert space methods compact embeddings solution theories and asymptotics electromagnetostatics time harmonic Maxwell s equations time dependent Maxwell s equations eddy current approximations scattering and radiation problems inverse problems finite element methods boundary element methods and isogeometric analysis

**Mathematical Analysis of Deterministic and Stochastic Problems in Complex Media Electromagnetics** G. F. Roach,I. G. Stratis,A. N. Yannacopoulos,2012-03-04 Electromagnetic complex media are artificial materials that affect the propagation of electromagnetic waves in surprising ways not usually seen in nature Because of their wide range of important applications these materials have been intensely studied over the past twenty five years mainly from the perspectives of physics and engineering But a body of rigorous mathematical theory has also gradually developed and this is the first book to present that theory Designed for researchers and advanced graduate students in applied mathematics electrical engineering and physics this book introduces the electromagnetics of complex media through a systematic state of the art account of their mathematical theory The book combines the study of well posedness homogenization and controllability of Maxwell equations complemented with constitutive relations describing complex media The book treats deterministic and stochastic problems both in the frequency and time domains It also covers computational aspects and scattering problems among other important topics Detailed appendices make the book self contained in terms of mathematical prerequisites and accessible to engineers and physicists as well as mathematicians

Electromagnetic Material Characterization of a Conductor-backed Material Using the Two Layer, Two Thickness, and Two Iris Waveguide Probe Methods Gary Dean Dester,2008

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

Radiating Nonuniform Transmission-Line Systems and the Partial Element Equivalent Circuit Method Prof. Dr. Juergen Nitsch, Dr. Frank Gronwald, Prof. Dr. Gunter Wollenberg, 2009-10-29 High frequencies of densely packed modern electronic equipment turn even the smallest piece of wire into a transmission line with signal retardation dispersion attenuation and distortion In electromagnetic environments with high power microwave or ultra wideband sources transmission lines pick up noise currents generated by external electromagnetic fields These are superimposed on essential signals the lines acting not only as receiving antennas but radiating parts of the signal energy into the environment This book is outstanding in its originality While many textbooks rephrase that which has been written before this book features an accessible introduction to the fundamentals of electromagnetics an explanation of the newest developments in transmission line theory featuring the transmission line super theory developed by the authors a unique exposition of the increasingly popular PEEC partial element equivalent circuit method including recent research results Both the Transmission Line Theory and the PEEC method are well suited to combine linear structures with circuit networks For engineers researchers and graduate students this text broadens insight into the basics of electrical engineering It provides a deeper understanding of Maxwellian circuit like representations of multi conductor transmission lines justifies future research in this field

*Electromagnetic Theory and Plasmonics for Engineers* Liudmila Nickelson, 2018-11-24 This book presents the theory of electromagnetic EM waves for upper undergraduate graduate and PhD level students in engineering It focuses on physics and microwave theory based on Maxwell's equations and the boundary conditions important for studying the operation of waveguides and resonators in a wide frequency range namely from approx  $10^9$  to  $10^{16}$  hertz The author also highlights various current topics in EM field theory such as plasmonic comprising a noble metal waveguides and analyses of attenuations by filled waveguide dielectrics or semiconductors and also by conducting waveguide walls Featuring a wide



variety of illustrations the book presents the calculated and schematic distributions of EM fields and currents in waveguides and resonators Further test questions are presented at the end of each chapter

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