

Antenna And Wave Propagation By K D Prasad

This is the first textbook that contains a holistic treatment of antennas both for traditional antennas mounted on masts (Line-of-Sight antenna systems) and for small antennas used on modern wireless devices such as smart phones being subject to signal variations (fading) due to multipath propagation. The focus is on characterization, as well as describing classical antennas by modern complex vector theory - thereby linking together many disciplines such as electromagnetic theory, classical antenna theory, wave propagation, and antenna system performance. Overall, this book represents a rethinking of the way basic antenna theory is presented. The book contains many references to important old and new papers and books on the analysis and design of the most useful antenna types, for the most interested readers.

In the offered book the fundamentals of electromagnetic fields and waves are discussed based on the great Maxwell equations. The book is conceived as a textbook for serious technical and classical universities in the considered themes. Nevertheless, it can be used, of course, as the reference book for wide group of engineers, researches and practical experts. Material of this book is divided into four main parts connected between them. The first part (Fundamental of Electrodynamics) is devoted to explanation of Maxwell equations and methods of its solutions. Besides classical interpretation the generalized equations are discussed, which take into consideration the scalar magnetic fields. New approaches allow description of so-called longitudinal electromagnetic waves, which have the absolutely non-standard propagation properties, and permit to explain various electrodynamics paradoxes, which cannot be explained in another way. The main characteristics of wave processes in the free space and in transmission lines (feeders) are described. The second part (Radio Wave Propagation) investigates the obvious patterns of diffraction and interference phenomena at radio wave propagation for the obstacle presence in the propagation track, which is typical for all practical situations. Radio wave propagation of various frequency ranges is fulfilled separately taking into consideration the specific features of reflections from the atmosphere parts, attenuation in different media, types of propagating waves, multipath effects, diffraction and non-standard conditions of obstacle overcoming including non-usual ways of atmosphere ducts. The third part is devoted to description of various types and antennas, beginning from simplest (vibrators) and ending by complicate adaptive antenna arrays. Description is fulfilled on the reviewing level with many obvious figures, not to rely on strict mathematical methods, but rather on the concept level. Fourth part includes description of UHF devices, which are the elements' base of UHF devices including surface and bulk integrated UHF circuits. These results have in many aspects the pioneer character and they are not widely known to experts. Distinctive feature of the offered book is sufficiently simplifies description of the very complicated electrodynamics problems available for the modern students and for young engineers. Of course, it is impossible to deal without mathematics in theses areas but required mathematics can be replaced by the many patterns, which give the chance to understand problems and to determine the complex questions. Sample Chapter(s) Chapter1: GENERAL DEFINITIONS AND RELATIONS OF ELECTRODYNAMICS (498 KB)Contents:FRONT MATTERCHAPTER 1. GENERAL DEFINITIONS AND RELATIONS OF ELECTRODYNAMICSCHAPTER 2. ELECTROMAGNETIC FIELDS AND WAVESCHAPTER 3. MAIN PHYSICAL PHENOMENA AT RADIO WAVES PROPAGATIONCHAPTER 4. PROPAGATION OF RADIO WAVES OF DIFFERENT RANGES AND ITS APPLICATION AREASCHAPTER 5. PRINCIPAL CHARACTERISTICS OF ANTENNASCHAPTER 6. ANTENNAS OF DECIMILLIMETER, MILLIMETER AND CENTIMETER WAVESCHAPTER 7. ANTENNAS OD DECIMETER, METER AND DECAMETER WAVESCHAPTER 8. ANTENNAS OF HECTOMETER, KILOMETER MYRIAMETER WAVESCHAPTER 9. ANTENNAS FOR TV, RADIO RELAY AND SPACE COMMUNICATION LINESCHAPTER 10. ELECTROMAGNETIC COMPATIBILITY OF RADIO ENGINEERING SYSTEMS. ANTENNAS AND THE PROBLEM OF ITS MINIATURIZATIONCHAPTER 11. MAIN COMPONENTS OF THE ELEMENT BASE OF ANTENNA-FEEDER ENGINEERINGCHAPTER 12. BASE ELEMENTS AND FUNCTIONAL UNITS OF ANTENNA- FEEDER ENGINEERINGBACK MATTERReadership: The book is conceived as a textbook for serious technical and classical universities in the considered themes. Nevertheless, it can be used, of course, as the reference book for wide group of engineers, researches and practical experts.

The book is primarily designed to cater to the needs of undergraduate and postgraduate students of Electronics and Communication Engineering and allied branches. It also caters for fundamental requirements of professionals working on design and development of antenna and wave propagation related equipment either in research laboratories or industries or academic institutions elsewhere. The book has been written with intent to grasp the basic understanding of theoretical as well as practical aspects of electromagnetic wave propagation and antenna engineering. The text has been aptly scripted considering the requirements of average students who can easily grasp and comprehend the basics of wave propagation and radiation mechanism of varieties of antennas coupled with their critical functionalities, utilities, advantages/disadvantages without any external assistance of teachers or other reference books. The book broaches very well on practical methods of parametric measurements of antenna with right measuring test equipment and associated tools. The last chapter of the book is dedicated to advance technology adopted in design and development of modern antenna. Key features

- A fairly large number of well labelled diagrams to provide practical understanding of the concepts.
- The placement of numericals at appropriate places develops confidence among readers and entuses them further to read in depth to crack any regular or competitive examinations.
- Chapter summary highlights important points for quick recap and revision before examination.
- Well-crafted multiple choice questions with answers at the end of each chapter to stimulate thought process and prepare better for viva-voce and competitive examinations.
- Appropriate number of unsolved numerical problems with answers to improve problem solving skill of students.

An accessible student-oriented approach to radiowave propagation Propagation-the process whereby a signal is conveyed between transmitter and receiver-has a profound influence on communication systems design. Radiowave Propagation provides an overview of the physical mechanisms that govern electromagnetic wave propagation in the Earth's troposphere and ionosphere. Developed in conjunction with a graduate-level wave propagation course at The Ohio State University, this text offers a balance of physical and empirical models to provide basic physical insight as well as practical methods for system design. Beginning with discussions of propagation media properties, plane waves, and antenna and system concepts, successive chapters consider the most important wave propagation mechanisms for frequencies ranging from LF up to the millimeter wave range, including: Direct line-of-sight propagation through the

atmosphere Rain attenuation The basic theory of reflection and refraction at material interfaces and in the Earth's atmosphere Reflection, refraction, and diffraction analysis in microwave link design for a specified terrain profile Empirical path loss models for point-to-point ground links Statistical fading models Standard techniques for prediction of ground wave propagation Ionospheric propagation, with emphasis on the skywave mechanism at MF and HF and on ionospheric perturbations for Earth-space links at VHF and higher frequencies A survey of other propagation mechanisms, including tropospheric scatter, meteor scatter, and propagation effects on GPS systems Radiowave Propagation incorporates fundamental materials to help senior undergraduate and graduate engineering students review and strengthen electromagnetic physics skills as well as the most current empirical methods recommended by the International Telecommunication Union. This book can also serve as a valuable teaching and reference text for engineers working with wireless communication, radar, or remote sensing systems. Clear, coherent work for graduate-level study discusses the Maxwell field equations, radiation from wire antennas, wave aspects of radio-astronomical antenna theory, the Doppler effect, and more.

One of the most methodical treatments of electromagnetic wave propagation, radiation, and scattering—including new applications and ideas Presented in two parts, this book takes an analytical approach on the subject and emphasizes new ideas and applications used today. Part one covers fundamentals of electromagnetic wave propagation, radiation, and scattering. It provides ample end-of-chapter problems and offers a 90-page solution manual to help readers check and comprehend their work. The second part of the book explores up-to-date applications of electromagnetic waves—including radiometry, geophysical remote sensing and imaging, and biomedical and signal processing applications. Written by a world renowned authority in the field of electromagnetic research, this new edition of *Electromagnetic Wave Propagation, Radiation, and Scattering: From Fundamentals to Applications* presents detailed applications with useful appendices, including mathematical formulas, Airy function, Abel's equation, Hilbert transform, and Riemann surfaces. The book also features newly revised material that focuses on the following topics: Statistical wave theories—which have been extensively applied to topics such as geophysical remote sensing, bio-electromagnetics, bio-optics, and bio-ultrasound imaging Integration of several distinct yet related disciplines, such as statistical wave theories, communications, signal processing, and time reversal imaging New phenomena of multiple scattering, such as coherent scattering and memory effects Multiphysics applications that combine theories for different physical phenomena, such as seismic coda waves, stochastic wave theory, heat diffusion, and temperature rise in biological and other media Metamaterials and solitons in optical fibers, nonlinear phenomena, and porous media Primarily a textbook for graduate courses in electrical engineering, *Electromagnetic Wave Propagation, Radiation, and Scattering* is also ideal for graduate students in bioengineering, geophysics, ocean engineering, and geophysical remote sensing. The book is also a useful reference for engineers and scientists working in fields such as geophysical remote sensing, bio-medical engineering in optics and ultrasound, and new materials and integration with signal processing.

The accurate design of earth-space systems requires a comprehensive understanding of the various propagation media and phenomena that differ depending on frequencies and types of applications. The choice of the relevant channel models is crucial in the design process and constitutes a key step in performance evaluation and testing of earth-space systems. The subject of this book is built around the two characteristic cases of satellite systems: fixed satellites and mobile satellite systems. *Radio Wave Propagation and Channel Modeling for Earth-Space Systems* discusses the state of the art in channel modeling and characterization of next-generation fixed multiple-antennas and mobile satellite systems, as well as propagation phenomena and fade mitigation techniques. The frequencies of interest range from 100 MHz to 100 GHz (from VHF to W band), whereas the use of optical free-space communications is envisaged. Examining recent research advances in space-time tropospheric propagation fields and optical satellite communication channel models, the book covers land mobile multiple antennas satellite- issues and relative propagation campaigns and stratospheric channel models for various applications and frequencies. It also presents research and well-accepted satellite community results for land mobile satellite and tropospheric attenuation time-series single link and field synthesizers. The book examines aeronautical communications channel characteristics and modeling, relative radio wave propagation campaigns, and stratospheric channel model for various applications and frequencies. Propagation effects on satellite navigation systems and the corresponding models are also covered.

Cylindrical arrays lie at the heart of the antenna systems of most major radio communication systems, including broadcasting networks, cellular 'phone systems and radar. In this book, the authors present practical theoretical methods for determining current distributions, input admittances and field patterns of a wide variety of cylindrical antennas, including the isolated antenna, the two-element array, the circular array, curtain arrays, Yagi and log-periodic arrays, planar arrays and three-dimensional arrays. Coverage includes analysis of horizontal antennas over, on and in the earth and sea, large resonant arrays of electrically short dipoles and a chapter on the theory and techniques of experimental measurement. Written by three of the leading engineers in the field, and based on world-class research carried out at Harvard over the last forty years, *Cylindrical Antennas and Arrays* is destined to become established as the basic reference for practising engineers and advanced students for many years to come.

Radio Wave Propagation: Consolidated Summary Technical Report of the Committee on Propagation of the National Defense Research Committee presents all the scientific information and report of experiments. This book discusses the problems encountered in the propagation of radio waves. Organized into three volumes, this book begins with an overview of the technical developments in the study of tropospheric propagation. This text then outlines the general theory of standard and nonstandard propagation together with descriptions and results of transmission experiments designed to test the theory. Other chapters consider the more unusual problems concerning the radar behavior of targets. This book discusses as well the problems of radio wave propagation in the standard atmosphere at frequencies above 30 megacycles. The final chapter deals with the selection and utilization of local terrain features that affect propagation and the performance of equipment. This book is a valuable resource for scientists and engineers in the field of radio wave propagation.

This completely updated second edition of an Artech House classic provides a thorough introduction to the basic principles of electromagnetic wave propagation of radio frequencies in real-world conditions, fully updated by including new achievements in theory and technology. It serves as an invaluable daily reference for practitioners in the field and as a complete, organized text on the subject. This comprehensive resource covers a wide range of essential topics, from the classification of radio waves, electromagnetic wave theory, and antennas for RF radio links,

to the impact of the earth surface on the propagation of ground waves, atmospheric effects in radio wave propagation, and radio wave reception. The book explores the propagation of the ground radio waves, namely the waves that propagate in vicinity of the earth's surface (e.g., guided by that interface), without involvement of any atmospheric effects. Specifics of the high-frequency (HF) radio propagation due to reflections from ionospheric layers is studied, based on commonly used models of the ionospheric vertical profiles. Scattering of the radio waves of UHF and higher frequency bands from the random variations of the tropospheric refraction index (from tiny air turbulences) are also considered by using the principles of statistical radio-physics. Analysis of propagation conditions on real propagation paths, including analysis of the power budget of the VHF/UHF link to assure its stability (percentage of availability within observation time frame), terrestrial, broadcast, mobile, and satellite RF links are presented. The engineering design of the cellular networks, including LTE 4G, 5G and upcoming higher generations is explored. HF propagation predictions for extremely long-range links design for commercial and military applications are explained. Packed with examples and problems, this book provides a theoretical background for astrophysical, aeronomy and geophysical instrumentation design.

This text should serve as an introduction to the application of electromagnetics EM, following an initial course in basic EM theory. A particular feature of the book is that it examines time domain rather than frequency domain methods in depth.; This book is intended for advanced undergraduate and graduates in electrical and electronic engineering. Research and practitioners in electromagnetics in electrical and electronic engineering and physics.

The aim of this book is to give an introduction to the fundamental principles of antennas and wave propagation. Unlike other books available, there is more emphasis on mathematical explanation in addition to physical understanding. Physical principles are explained in detail with clear diagrams to support the theory.

Antenna is an array of conductors. It is the interface between radio waves which propagate through electric and space currents in metal conductors. They are required by transmitters and radio receivers to combine its electrical connection to electromagnetic field. Radio waves are electromagnetic waves. They carry signals at the speed of light through air without any transmission loss. They can be classified by operating principles or applications. Antennas are classified as omnidirectional or directional. Other types include whip antenna, dipole antenna, etc. Antennas and propagation act as keys for any radio system. Wave propagation is the study of the ways in which waves travel. The study of radio wave's behavior while traveling from one point to another is known as radio propagation. Most of the topics introduced in this book cover new techniques and the applications of antennas and wave propagation. It aims to shed light on some of the unexplored aspects of this field. It will serve as a valuable source of reference for those interested in antennas and wave propagation.

This comprehensive guide helps readers understand the theory and techniques needed to analyze and model radio wave propagation in complex environments. All of the essential topics are covered, from the fundamental concepts of radio systems, to complex propagation phenomena. These topics include diffraction, ray tracing, scattering, atmospheric ducting, ionospheric ducting, scintillation, and propagation through both urban and non-urban environments. Emphasis is placed on practical procedures, with detailed discussion of numerical and mathematical methods providing readers with the necessary skills to build their own propagation models and develop their own techniques. MATLAB functions illustrating key modeling ideas are provided online. This is an invaluable resource for anyone wanting to use propagation models to understand the performance of radio systems for navigation, radar, communications, or broadcasting.

An introduction to RF propagation that spans all wireless applications This book provides readers with a solid understanding of the concepts involved in the propagation of electromagnetic waves and of the commonly used modeling techniques. While many books cover RF propagation, most are geared to cellular telephone systems and, therefore, are limited in scope. This title is comprehensive-it treats the growing number of wireless applications that range well beyond the mobile telecommunications industry, including radar and satellite communications. The author's straightforward, clear style makes it easy for readers to gain the necessary background in electromagnetics, communication theory, and probability, so they can advance to propagation models for near-earth, indoor, and earth-space propagation. Critical topics that readers would otherwise have to search a number of resources to find are included: * RF safety chapter provides a concise presentation of FCC recommendations, including application examples, and prepares readers to work with real-world propagating systems * Antenna chapter provides an introduction to a wide variety of antennas and techniques for antenna analysis, including a detailed treatment of antenna polarization and axial ratio; the chapter contains a set of curves that permit readers to estimate polarization loss due to axial ratio mismatch between transmitting and receiving antennas without performing detailed calculations * Atmospheric effects chapter provides curves of typical atmospheric loss, so that expected loss can be determined easily * Rain attenuation chapter features a summary of how to apply the ITU and Crane rain models * Satellite communication chapter provides the details of earth-space propagation analysis including rain attenuation, atmospheric absorption, path length determination and noise temperature determination Examples of widely used models provide all the details and information needed to allow readers to apply the models with confidence. References, provided throughout the book, enable readers to explore particular topics in greater depth. Additionally, an accompanying Wiley ftp site provides supporting MathCad files for select figures in the book. With its emphasis on fundamentals, detailed examples, and comprehensive coverage of models and applications, this is an excellent text for upper-level undergraduate or graduate students, or for the practicing engineer who needs to develop an understanding of propagation phenomena.

This text book on "Antennas and Radio-wave Propagation" describes the theory of various types of antennas that are in current use and the way in which the radiated waves get propagated through space. The theory has been written in a simple and easy-to-understand language. Lots of worked-out examples as well as diagrams in 2-D and 3-D have been included to illustrate the principles clearly. It is hoped that these features help the students to grasp the theories involved easily. Features Provided solid grasp of the

subject. Every concept is explained in detail with 2 dimension or 3 dimension figures wherever necessary. Every chapter is fortified with lots of worked examples. Each chapter ends with review questions and exercise problems to allow the student to test their understanding of the material covered. Basic principles on antenna and special antennas are discussed in appendices Contents Antenna Basics Point Sources Antenna Arrays Electric Dipole and Thin Linear Antennas The Loop Antenna The Helical Antenna and the Yagi-Ud array Antenna Types Propagation of Ground and Space Waves Sky-Wave Propagation Appendices.

This work treats the essential elements of radio wave propagation without requiring recourse to advanced electromagnetic concepts and equations. However, it provides sufficient detail to allow those concerned with wireless systems to acquire quickly a practical working knowledge of the important concepts. Radio wave propagation is placed in a practical context by considering the design aspects of communications systems at microwave frequencies. A fuller consideration of the electromagnetic properties of materials is given late in the book rather than as an introductory chapter.

Aimed at a single-semester course on antennas at the undergraduate level, Antennas and Wave Propagation provides a lucid explanation of the fundamentals of antennas and propagation. This student-friendly text also includes simple design procedures along with a large number of examples and exercises.

Antennas and Wave Propagation is written for the first course on the same. The book begins with an introduction that discusses the fundamental concepts, notations, representation and principles that govern the field of antennas. A separate chapter on mathematical preliminaries is discussed followed by chapters on every aspect of antennas from Maxwell's equations to antenna array analysis, antenna array synthesis, antenna measurements and wave propagation.

This book emerged from teaching a graduate level course in propagation and smart antennas at the Naval Postgraduate School. In its present form, it is suitable not only as a graduate level text, but also as a reference book for industry and research use. The area of radiowave propagation and smart antennas is highly interdisciplinary, extracting material from electromagnetics, communications, and signal processing. This book is useful to workers in electromagnetics who would like to supplement their background with relevant communicational aspects and to workers in communications who would like to supplement their background with relevant electromagnetic aspects. Anyone with a basic understanding of probability, wave propagation, digital communications, and elementary signal processing should be able to appreciate the contents of the book. The book consists of nine chapters with several worked out examples dispersed throughout. Chapter 1 covers the basics of cellular communications. Chapter 2 covers the basic principles of electromagnetic wave propagation relevant to path loss predictions in wireless communications. Students with little prior background in electromagnetics should find the first few sections of Chapter 2 self-sufficient. Empirical path loss models that are used in system design are treated in Chapter 3. The chapter includes the traditional models as well as some of the newer models. Chapter 4 has a thorough discussion on the causes and characterization of small scale fading. The topic of spatial correlation that is very important for antenna arrays is discussed there in detail.

This book is designed for the final year students in electronics and communication and for the first year post graduate students in Digital Communication and allied subjects. This compact and comprehensive text fulfils the long felt need for a suitable text book in the area of "Antenna and wave Propagation". It is written as per the revised syllabus of Rajasthan Technical University (RTU), Kota. It covers the topics, of fundamentals of antenna, types of antenna, antenna arrays, radio propagation modes, with basics of IE3D software and advance antenna topics. This well organized text lays emphasis on all the modes of propagation and practical aspects of antenna, with worked out examples & further previous year solved paper are included topic wise, which would be of considerable assistance to the reader. This comprehensive book covering all aspects of antenna and wave propagations, should prove to be an invaluable asset to both students & professionals. Features: According to the syllabus prescribed by Rajasthan Technical University (RTU), Kota. Including previous year's university papers. Precise definitions and clear exposure of fundamental concepts. Simple and easy explanation of the topics along with well labelled diagrams. Step by step procedure is followed for explaining the topics. Detailed coverage of advance antennas, helpful for the post graduation students. The recent applications of antenna are also summarized here again proving fruitful for the M.Tech. Students. IE3D software basic is been included for the purpose of dissertation for M. Tech. Students. Ideally suitable for self study.

Antennas and radio propagation are continuously and rapidly evolving and new challenges arise every day. As a result of these rapid changes the need for up-to-date texts that address this growing field from an interdisciplinary perspective persists. This book, organized into nine chapters, presents new antenna designs and materials that will be used in the future, due to the trend for higher frequencies, as well as a bird's eye view of some aspects related to radio propagation channel modeling. The book covers the theory but also the practical aspects of technology implementation in a way that is suitable for undergraduate and graduate-level students, as well as researchers and professional engineers.

Substrate-Integrated Millimeter-Wave Antennas for Next-Generation Communication and Radar Systems The first and only comprehensive text on substrate-integrated mmW antenna technology, state-of-the-art antenna design, and emerging wireless applications Substrate-Integrated Millimeter-Wave Antennas for Next-Generation Communication and Radar Systems elaborates the most important topics related to revolutionary millimeter-wave (mmW) technology. Following a clear description of fundamental concepts including substrate-integrated waveguides and loss analysis, the text treats key design methods, prototyping techniques, and experimental setup and testing. The authors also highlight applications of mmW antennas in 5G wireless communication and next-generation radar systems. Readers are prepared to put techniques into practice through practical discussions of how to set up testing for impedance matching, radiation patterns, gain from 24GHz up to 325 GHz, and more. This book will bring readers state-of-the-art designs and recent progress in substrate-integrated mmW antennas for emerging wireless applications. Substrate-Integrated Millimeter-Wave Antennas for Next-Generation Communication and Radar Systems is the first comprehensive text on the topic, allowing readers to quickly master mmW technology. This book: Introduces basic concepts such as metamaterials Huygens's surface, zero-index structures, and pattern synthesis Describes prototyping in the form of fabrication based on printed-circuit-board, low-temperature-co-fired-ceramic and micromachining Explores applications for next-generation radar and imaging systems such as 24-GHz and 77-GHz vehicular radar systems Elaborates design methods including waveguide-based feeding network, three-dimensional feeding structure, dielectric loaded

aperture antenna element, and low-sidelobe synthesis The mmW is one of today's most important emerging technologies. This book provides graduate students, researchers, and engineers with the knowledge they need to deploy mmW systems and develop new antenna designs with low cost, low loss, and low complexity.

Antennas and Wave Propagation Pearson Education India

An important resource that examines the physical aspects of wireless communications based on mathematical and physical evidence The Physics and Mathematics of Electromagnetic Wave Propagation in Cellular Wireless Communication describes the electromagnetic principles for designing a cellular wireless system and includes the subtle electromagnetic principles that are often overlooked in designing such a system. This important text explores both the physics and mathematical concepts used in deploying antennas for transmission and reception of electromagnetic signals and examines how to select the proper methodology from a wide range of scenarios. In this much-needed guide, the authors—noted experts in the field—explore the principle of electromagnetics as developed through the Maxwellian principles and describe the properties of an antenna in the frequency domain. The text also includes a review of the characterization of propagation path loss in a cellular wireless environment and examines ultrawideband antennas and the mechanisms of broadband transmission of both power and information. This important resource: Includes a discussion of the shortcomings of a MIMO system from both theoretical and practical aspects Demonstrates how to deploy base station antennas with better efficiency Validates the principle and the theoretical analysis of electromagnetic propagation in cellular wireless communication Contains results of experiments that are solidly grounded in mathematics and physics Written for engineers, researchers, and educators who are or plan to work in the field, The Physics and Mathematics of Electromagnetic Wave Propagation in Cellular Wireless Communication offers an essential resource for understanding the principles underpinning wireless communications.

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Discusses general concepts and illustrates them with specific examples and references from a variety of antenna systems. This title covers contents related to antenna arrays. It examines more than 100 common antenna working behaviour questions. It clarifies what you need to know about antenna arrays in a 3D manner and various arrangements.

The goal of this book is to discuss fundamentals of electromagnetic wave propagation, especially radiowave propagation, groundwave propagation, surface wave propagation, maritime communication, radar applications in terms of parabolic equation modeling and simulation approaches This is the first book on the guided wave propagation model in nearly two decades. This book will cover several new applications. The book also introduces several simple and sophisticated MATLAB scripts as well as virtual electromagnetic tools for several well-known electromagnetic propagation problems.

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