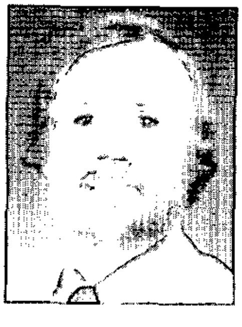

Allen Glisson
Dept. of Electrical Engineering
University of Mississippi
PO Box 1848
University, MS 38677-1848 USA
+1 (662) 915-5353
+1 (662) 915-2731 (Fax)
aglisson@olemiss.edu (e-mail)

Wireless Communications, by Andrea Goldsmith, Cambridge, Cambridge University Press, 2005, xxviii + 644 pages, $75.00, ISBN 0-521-83716-2.

Wireless Communications, prepared by Andrea Goldsmith, is a very good book that balances the theory and practice in wireless technology.

First of all, the reader should keep in mind that the reviewer is a university professor with an electromagnetics background, and this review basically targets the Antennas and Propagation Society (AP-S). Secondly, it should also be kept in mind that wireless technology enables multimedia communications among people and devices from any location. Therefore, locating a subscriber wherever he/she is on the Earth among billions of globally distributed mobile terminals, within tens of thousands of complex wireless sub-networks, is a real challenge!

Before reviewing the book, I believe there is a need to state what we – as the members of the AP-S – expect from a book on wireless communication. I know many of the AP-S members teach undergraduate introductory levels of wireless or cellular communications lectures. I also do, beside the electromagnetics (EM) lectures, and, in addition, "Numerical Analysis" and "Probability and Stochastic Processes." This is a real opportunity for me to gradually prepare students, starting from "Numerical Analysis" and "Probability and Stochastic Processes" towards wireless communication lectures via the classical EM lectures (such as "EM Field Theory," "EM Wave Theory," and "Antennas and Propagation"). I enjoy using *MATLAB*-based scripts as much as possible in all these lectures, and urge the students to simulate basic physical events, either deterministic or stochastic, via take-homes, computer lab experimentations, term projects, etc. I coordinate these computer simulations in a way that when it comes to wireless communication lectures at the end, the students have already been experienced in, or equipped with, the stochastic signal generation with amplitude, frequency, and phase fluctuations that obey some given probability density functions, as well as specified power spectra (or autocorrelation functions), for specified signal-to-noise (SNR) and/or signal-to-interference (SIR) ratios. Therefore, they can directly focus on path-loss modeling, signal fluctuations and fading characteristics, digital signal simulations with a given bit-error rate (BER) and transmission speed in bits per second (BPS), computer simulations of channel modeling, cellular system design and traffic calculations, and, finally, the modulation and system aspects.

The book *Wireless Communications* is well structured, well written, and reader-friendly. Obviously, the author has an expertise in adaptive modulation techniques, channel modeling, MIMO, equalization, and multi-component and ad hoc systems that comes from years of wireless lecturing and industrial practice studies. The book therefore shows that it is a product of years of teaching and research experience. It offers an up-to-date and quite comprehensive resource, not only for university students, but also for lecturers, engineers, practitioners, and researchers. It includes both fundamentals and the most recent developments in wireless communication systems.

The book is divided into three segments: Chapters 1 to 6 are the first part, Chapters 7 to 13 are the middle part, and the remaining three chapters form the last part. As mentioned by the publisher,

> ...the book starts with an overview of wireless systems and standards. The characteristics of the wireless channel are then described, including capacity limitations. Various modulation, coding, and signal processing schemes are then discussed in detail, including state-of-the-art adaptive modulation, multicarrier, spread spectrum, and multiple antenna techniques. The concluding chapters deal with multiuser communications, cellular system design, and ad hoc wireless network design.

Chapter 1 is reserved for a historical review of wireless communications, current systems and standards, as well as some futuristic projections. Chapters 2 and 3 discuss wireless channel characteristics, and particularly cover path loss, shadowing, and multipath effects of fast/slow fading. The well-known path-loss models – the Okumura model, the Hata model, and its COST 231 extension – are given in Chapter 2. In addition to the path-loss models, shadowing, which has important implications for wireless system design, is also discussed. The time-varying channel impulse response, narrow- and wideband fading, as well as discrete-time and space-time channel models, are presented in Chapter 3. Fundamental wireless channel capacity limits, along with the capacity-achieving transmission strategies, are treated in Chapter 4. First, the well-known formula for the capacity of a single-user time-invariant additive white Gaussian noise (AWGN) channel is summarized, and the Shannon capacity of a fading channel under different conditions is given. Then, the comparisons of the capacities of the frequency-selective fading channels for both time-invariant and time-varying channels are presented.

In Chapters 5 and 6, the author focuses on digital modulation techniques and their performance in wireless channels. Advantages and restrictions of digital modulation are first given in Chapter 5.

Geometrical representations of wireless signals, various digital amplitude, frequency and phase modulation techniques, and symbol synchronization and receiver structure with phase and timing recovery are all outlined in this chapter. Wireless channel modeling is given in Chapter 6. The AWGN channels are reviewed under different modulation techniques, including PSK, BPSK, QPSK, MPSK, MPAM, MQAM, FSK, and CPFSK. Fading and Doppler effects on wireless channels are also discussed in this chapter.

Transmitter and receiver diversities are some of the best techniques for mitigating the effects of fading. Chapter 7 covers the discussions of diversity techniques. Mitigation of multipath fading, called microdiversity, and shadowing, called macrodiversity, are reviewed in this chapter. Space, frequency, time, and polarization diversity approaches are accordingly compared. Bit errors introduced during wireless transmission can be detected and corrected by using various source- as well as channel-coding techniques. Chapter 8 provides a comprehensive discussion of coding techniques, including mature methods for block, convolutional, trellis, turbo coding, and LDPC codes.

Adaptive modulation combined with coding also enhances the transmission over time-varying channels. The basic idea is to estimate the time characteristics of the channel at the receiver, and to provide feedback to the transmitter so that the transmission scheme can be adaptive. The treatment of adaptive modulation in flat fading is given in Chapter 9. Adaptive techniques such as variable rate, variable power, variable error probability, and variable coding are covered in this chapter, together with their hybridization. Multiple antenna techniques and space-time communication systems are discussed in Chapter 10. Wireless multiple-input, multiple-output (MIMO) models, MIMO channel capacity, MIMO diversity gain (i.e., beamforming), and the smart antenna concepts are summarized.

Delay spread in wireless transmission causes inter-symbol interference (ISI), which may result in severe irreducible error. Equalization is an approach to solve the inter-symbol interference problem. Establishing a balance between inter-symbol interference mitigation and noise enhancement is the major concern in equalization design. Chapter 11 covers equalization, the signal compensation techniques for frequency-selective fading. The data transmitting rate can be significantly increased by the application of multi-carrier modulation (i.e., sending information over many different sub-channels). Multi-carrier modulation, which has been known since the late 1950s and applied to military HF (3-30 MHz) systems, is described in Chapter 12. Both single- and multi-user spread-spectrum techniques are presented in Chapter 13. Spread spectrum allows multiple users to share the same signal bandwidth, since spread signals can be superimposed on top of each other and can be transmitted over the same channel.

The last three chapters of the book focus on multi-user systems and networks. Chapter 14 treats multiple- and random-access techniques for sharing the wireless channel among many users with continuous or bursty data. Frequency-division multiple access (FDMA), time-division multiple access (TDMA), code-division multiple access (CDMA), and space-division multiple access (SDMA) are all discussed in this chapter. The design, optimization, and performance analysis of cellular systems, including power control, is given in Chapter 15. Channel reuse, interference-reduction techniques, dynamic resource allocation, and data transmission rate limits are reviewed briefly. Ad hoc wireless home, data, device, sensor networks, future trends, and open research challenges are discussed in the last chapter, Chapter 16.

The three appendices – Appendix A for the fundamental low-pass and bandpass signal representations, Appendix B for the main concepts of probability and random processes, and Appendix C for the summary of matrix algebra – summarize the key background that the author believes helpful and necessary for the reader. Current wireless systems and standards are given in Appendix D.

A broad list of references at the end of each chapter and a huge bibliography of nearly twenty-five pages at the end of the book are other valuable features of the book.

There are nearly one hundred worked examples, located here and there in the proper places in each chapter, which highlight key principles and trade-offs. There are also about three hundred homework exercises for the students/lecturers who plan to use the book as a textbook. The solutions manual, which contains some interesting and educational *MATLAB* scripts, is available to the reader on the Web.

The book may be used as a textbook and/or lecture notes, depending on the type and length of the course, student background, and course focus. The core of the book is in Chapters 1 through 6, and may be used in introductory level lectures on wireless communication (I think this core part could have been kept shorter and simpler for the undergraduate-level wireless lectures). The rest of the chapters cover different stand-alone topics that can be covered in other courses. The natural segmentation of the book permits it to be covered in a two- or three-quarter lecture sequence. I like the alternatives proposed by the author for the lecturing:

- A one-semester lecture could focus on single-user wireless systems, based on the core material in Chapters 1-6 and selected topics from Chapters 7-13. In this case, a second optional quarter or semester could be offered, covering multi-user systems and wireless networks (part of Chapter 13 and Chapters 14-16).

- For a two-semester lecture, the first course could focus on Chapters 1-10 (single-user systems with flat fading), and the second course could focus on Chapters 11-16 (frequency-selective fading techniques, multi-user systems, and wireless networks).

- Alternatively, a one-semester lecture could cover both single- and multi-user systems based on Chapters 1-6 and Chapters 13-16, with some additional topics from Chapters 7-12 as time permits.

Writing a book in some areas or topics is an extremely difficult task in terms of the specifications of subtopics or chapters, as well as their contents. If "radar" is one of these areas, "wireless" certainly is the other: they both necessitate a *systems approach*, and require the inclusion of communication, antennas, propagation, channel modeling, modulation and coding, traffic calculations, stochastic characteristics of signals (i.e., noise, interference, clutter, communication signals, etc.), spectrum management, novel spread-spectrum techniques, frequency- and time-domain characteristics, practical realization of systems and sub-units, etc. I believe the author has completed this difficult task with great success.

In conclusion, the book *Wireless Communications* is a comprehensive resource, and is unique in terms of emphasizing the core principles of wireless system design and covering the state-of-the-art topics such as space-time coding, dynamic resource allocation, and ad-hoc networks, etc., at the same time. It should be of interest to anyone who is interested in wireless communications.

Reviewed by:

Levent Sevgi
Electronics and Communication Engineering Dept.
DOĞUŞ University, Istanbul
Turkey
E-mail: lsevgi@dogus.edu.tr

Applied Electromagnetics and Electromagnetic Compatibility, by Dipak L. Sengupta and Valdis V. Liepa, Hoboken, NJ, John Wiley & Sons, 2006, xxii + 486 pages, $74.95, ISBN 0-471-16549-2.

With increased crowding of the electromagnetic spectrum and tighter regulation of electromagnetic compatibility (EMC), there is a growing demand from industry for electrical engineering (EE) graduates with an EMC background. Currently, only a few undergraduate electrical engineering programs in the United States address EMC issues directly, although most electrical engineering programs require at least one course in electromagnetics (EM). In teaching a senior/graduate EMC course to practicing engineers and electrical engineering students, the authors found that most class students did not have a sufficient background in Maxwell's equations and related EM topics to deal with EMC problems. So the authors decided to write a textbook combining the fundamentals of EM fields and waves and EMC. Most of the chapters have problems (some with solutions) included at the end.

A chapter-by-chapter description follows.

Chapter 1 is a short introduction to electromagnetic interference (EMI), with some practical examples of EMI. Common definitions and terminology are also given.

Chapter 2 is a short, but important, summary of the electromagnetic environment. Tables of natural and manmade noise sources, along with some of their properties (frequency range and electric and magnetic field strengths), are provided.

Chapter 3 is a long treatment of the fundamentals of EM fields and waves. It contains much of what would be covered in a basic beginning EM fields course. Maxwell's equations in integral and differential forms are covered in both the time and frequency domains. This is followed by boundary conditions, Poynting's theorem, and uniqueness. Time-harmonic fields and phasor notation are introduced for use throughout the book. The wave equation is derived, and plane-wave solutions are obtained. Lossy, dispersive media are described, and the concept of group velocity is introduced. The chapter concludes by treating the case of plane-wave reflection and refraction at a planar interface for both normal and oblique incidence. To make the numerous concepts of this long chapter easier to understand, a number of example problems with detailed solutions are interspersed throughout.

Chapter 4 covers signal waveforms and spectral analysis. This is the first of four chapters (Chapters 4-7) that begin to provide the special background needed for EMC analysis. Periodic and finite-duration waveforms are treated, and spectral properties are obtained via the Fourier series and integral. Examples of commonly encountered waveforms are given.

Chapter 5 provides an introduction to transmission lines. General transmission-line theory and the telegrapher's equations are introduced. Transmission-line parameters are derived for several common TEM lines and for microstrip lines (quasi-TEM). Terminated transmission lines are studied, both in the time and frequency domains. The chapter concludes with a short section on transmission-line measurement techniques.

Chapter 6 is a long chapter on antennas and radiation. The scalar and magnetic vector potentials are introduced for deriving the fields radiated by an arbitrary current distribution. Radiation by Hertzian dipoles, small loops, linear antennas, and array antennas are treated in detail. Standard antenna properties and definitions are discussed. For receiving antennas, the concepts of effective area and equivalent circuit are introduced. The chapter concludes with a treatment of biconical antennas, because they are commonly used in EMC measurements.

Chapter 7 covers the behavior of circuit components (R, L, C) from an EM-theory point of view. This allows quantities such as mutual inductance to be derived in a natural manner.

The final six chapters (Chapters 8-13) all deal with EMC topics. Chapter 8 provides an introduction to radiated emissions and susceptibility. (I would have preferred to see the use of the more modern term immunity, the complement of susceptibility, but the authors do use immunity in some cases.) Emissions from a linear element and a pair of currents are analyzed, and this provides a good opportunity to introduce the concepts of differential-mode emissions and common-mode emissions (which circuit designers are always trying to avoid). The use of transmission-line theory is used to study pickup from incident fields in immunity applications.

Chapter 9 covers electromagnetic shielding. The commonly used term shielding effectiveness (SE) is discussed and defined. The lossy slab is the only model analyzed, but it is treated for both plane-wave (far-field) and near-field illumination where the electric- and magnetic-field shielding effectiveness values are different.

Chapter 10 is a short treatment of coupling between devices. It covers both inductive and capacitive coupling between simple circuits, and shows the typical frequency dependence.

Chapter 11 is a short, but practical, treatment of electrostatic discharge (ESD). It discusses typical causes and consequences of ESD, and gives examples of ESD current waveforms. ESD generators and test methods are discussed.

Chapter 12 covers EMC standards, a very important topic for designers who need to meet these standards in order to market electronic devices. Both US and European standards for radiated and conducted emissions are illustrated in tables and graphs. It would have been useful to cover immunity standards (which are included in military and European standards), but references are given.

Chapter 13 is a short chapter on measurements of conducted and radiated emissions. It includes two terms that are important in emissions measurements (but probably not well known to the AP-S community): line impedance stabilization network (LISN) and antenna factor (AF).

The book includes three appendices. Appendix A, "Vectors and Vector Analysis," covers many topics of importance to basic EM theory. Appendix B, "Frequency Band Designations," includes a number of tables on frequency bands and their typical use. Appendix C, "Constitutive Relations," has a number of useful tables on the EM properties of materials.

In summary, the authors have accomplished their goal of including basic EM theory and a good introduction to EMC in one book. The book is clearly written, and I found only a few typos. However, in covering two topics that would normally be covered in separate books, the authors were forced to sacrifice depth in the EMC chapters. The reader is furnished with an introduction to EMC, but will need to seek other sources, such as [1], if he or she would like more in-depth knowledge. Also, I would like to have seen more coverage of EM immunity measurements and standards, which are treated very lightly compared to EM emissions.

Reference

1. C. R. Paul, *Introduction to Electromagnetic Compatibility*, New York, Wiley, 1992.

Reviewed by:

David A. Hill
Electromagnetics Division
National Institute of Standards and Technology
325 Broadway
Boulder, CO 80305 USA
E-mail: dhill@boulder.nist.gov

RF/Microwave Interaction with Biological Tissues, by André Vander Vorst, Arye Rosen, and Youji Kotsuka, New York, IEEE Press/John Wiley, 2006, 344 pages, $94.95, ISBN: 0-471-73277-X.

Substantial research has been conducted on the biological effects, both positive and negative, of RF/microwave fields. A vast number of applications have been explored, ranging from hyperthermia and therapeutic medicine to the effects of cell-phone radiation and specific-absorption rate (SAR) calculations. Although research in these areas is prevalent both in RF/microwave and medical literature, surprisingly few books have been written that tie all of these disjoint applications into a coherent whole. Many of the books available today are just a compilation of related journal articles, still leaving the need for a cohesive text, connecting today's applications with the underlying theory. The new book, *RF/Microwave Interaction with Biological Tissues*, by Andre Vander Vorst, Arye Rosen, and Youji Kotsuka, addresses this need.

A comprehensive overview of fundamental concepts and theory is first presented, including electromagnetics (EM) in multilayer lossy media, bioelectricity, tissue characterization, absorption, and modeling of specific areas of the body (e.g. nervous system, cells, heart, eye, etc.). This is supplemented with relevant experiments that closely follow these theoretical concepts. The last three chapters present a complete overview of current applications in thermal therapy, EM-wave absorption, and therapeutic medicine. Complete descriptions of these systems are presented, including theory and experimental setup. Each chapter contains in-depth, challenging problems, which make this book an excellent choice for a graduate course.

This book is a great resource, which bridges the gap between the world of today's RF/microwave engineers working in biomedical applications and the world of those in the medical community. It is well thought out, comprehensive, easy to follow, practical, contains a wealth of excellent examples and references, and has many instructive exercise problems. The book touches on a variety of microwave issues, including dielectric-constant measurements of biological tissues, microwave propagation in lossy media, electromagnetic modeling in complicated non-homogeneous lossy time- and frequency-dependent media, and exposure measurements and radiation hazards highlighting safety standards. In addition, biological concepts of the nervous and other systems are presented in the context of RF/microwaves. Finally, information is presented on many applications, including dosimetry, thermal therapy, and therapeutic medicine. The authors have successfully transferred their breadth and depth of experience into an exciting, readable book comprised of six concise chapters.

One goal of the authors for this book is its use in graduate-level engineering courses, in order to encourage further research in the unique area of RF/microwave interaction with biological tissues. This has been accomplished successfully at the University of Tennessee, where a new multi-disciplinary course is being taught on RF/microwave interaction with biological tissues for graduate students in both the ECE and Biomedical departments. This book was utilized as the textbook, with extensive use of the exercise problems both for homework and as part of the class notes. The book was completely covered in a one-term course. The text and example problems were supplemented with two class projects: one to carry out dielectric-constant measurements of biological tissues, and the other on FDTD modeling of wave propagation in lossy media.

The book begins with an introductory chapter that summarizes electromagnetic fundamentals as related to biological mechanisms. Basic background material includes Maxwell's equations for time-varying fields, antenna near-field radiation, and blackbody radiation. This is followed by a comprehensive discussion of microwave penetration into tissues, their associated relaxation effects, various dielectric-constant theoretical models, and display techniques, such as the Cole-Cole diagram. A comprehensive overview of necessary EM theory is presented in this chapter in a manner that makes it easy to read and follow for both ECE and biomedical graduate students.

The next chapter is a review of biology materials fundamentals, stressing the interaction between biological tissues and the RF fields. This chapter emphasizes bioelectricity phenomena in cells and nerves, tissue characterization, dielectric dispersion, and measurements of both tissues and liquids, including temperature effects. The discussion on tissue characterization is complete, with detailed information on measurement techniques and related issues.

The third chapter addresses the focus of the book. It discusses in detail the absorption of RF radiation, namely SAR concepts, including measurement techniques, computational methods, modeling and simulation of the nervous system, radiation hazards, and exposure standards. Other topics touched upon include the influence of drugs, non-thermal, micro-thermal, and isothermal effects on biological tissues, and a review of many epidemiology studies. The chapter includes a long list of references (123), and cites numerous studies for further research and investigation. Excellent, practical problems that are useful in understanding absorption concepts are contained at the end of the chapter.

Microwaves have been used for more than 30 years in thermal therapy, and Chapter 4 is entirely devoted to medical treatment using thermotherapy techniques. This chapter describes heating principles in detail, including RF/microwave dielectric and inductive heating. Examples of actual dielectric-heating applicators are also presented. Then, a brief background discussion on hyperthermia and its effects on biological tissues are presented, followed by a discussion on methods of invasive and noninvasive thermometry. In addition, a complete list of thermocouple materials and thermistor sensors is given. This chapter is very informative, and is presented in a concise and readable manner.

As the use of RF/microwave radiators continues to increase, the topic of radiation absorption continues to be of increasing interest to many users. An overview of various ferrite absorbers, including multilayer, quarter-wavelength, multi-hole, and pyramidal EM-wave absorbers, is presented. Absorbing materials are essential to protect biological and medical environments, and this chapter concludes by discussing specific methods for improving field distribution in a small room. This chapter is of high importance for anyone working in the health safety field.

The last chapter is very interesting, and is fully devoted to surveying various therapeutic applications of RF/microwave delivery systems. Although many therapeutic applications are presented, the subject of treatment by cardiac ablation is presented in depth, due to the authors' firsthand experience in developing the system. Plenty of new ideas and novel concepts on the future of therapeutic applications and measurement techniques, including blood perfusion, are included here, with over 140 references. It is a must-read chapter, as it lays out the benefits of using RF/microwaves in the medical field. Again, the practice problems here were used as part of the class notes to emphasize applications. The students were fascinated with the wide variety of applications covered, including endometrial ablation, liposuction, the treatment of gastroesophageal reflux disease, microwave balloon angioplasty, and many others.

This is a powerful book that every scientist and engineer working in the area of biomedical applications of RF/microwaves should read and keep for reference. It is a self-contained course for readers with RF or biology backgrounds, but is useful to a wider audience of engineers and medical specialists, since the material is presented in a concise way, emphasizing core concepts and relevant examples. I am very impressed with the clarity with which this book was written, as well with its wealth of information, all contained in a book of this length. This is an excellent book; we need more like it.

Reviewed by:

Aly E. Fathy
Electrical and Computer Engineering Department
University of Tennessee
E-mail: fathy@ece.utk.edu

Mohamed Mahfouz
Biomedical Department
University of Tennessee
E-mail: mmahfouz@utk.edu

EMP Note Series Information

Stephanee Campbell has moved to a new position at AFRL. Please send CD Note collection requests (*Sensor and Simulation Notes* 1-422, *Interaction Notes* 1-568, and *Miscellaneous Notes*), and address or e-mail changes, to Dr. Carl Baum's assistant, Chuck Reuben, at Tel: +1 (505) 277-1082; e-mail: shawnee@unm.edu.

Recent Books

The following is a list of recently published books that have been received by the Associate Editor since the last issue of the *Magazine* was published. Reviewers are sought for these books, so readers are encouraged to let the Associate Editor know if they are interested in reviewing a particular book.

Orthogonal Methods for Array Synthesis: Theory and the ORAMA Computer Tool, by John N. Sahalos. (John Wiley, 2006)

ELINT: The Interception and Analysis of Radar Signals, by Richard G. Wiley (Artech House, 2006)

Electrically Small, Superdirective, and Superconducting Antennas, by R. C. Hansen (John Wiley, 2006)

Metamaterials: Physics and Engineering Explorations, edited by Nader Engheta and Richard W. Ziolkowski (IEEE Press/John Wiley 2006)

Asymmetric Passive Components in Microwave Integrated Circuits, by Hee-Ran Ahn (John Wiley, 2006)

Spaceborne Antennas for Planetary Exploration, edited by William A. Imbriale (John Wiley, 2006)