

# DIGITAL AND ANALOG COMMUNICATION SYSTEMS

**Eighth Edition**

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**PEARSON**

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*To my wife, Margaret Wheland Couch,  
and to our children,  
Leon III, Jonathan, and Rebecca*

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# PREFACE

Continuing the tradition of the first through the seventh editions of *Digital and Analog Communication Systems*, this eighth edition provides the latest up-to-date treatment of digital communication systems. It is written as a textbook for junior or senior engineering students and is also appropriate for an introductory graduate course. It also provides a modern technical reference for the practicing electrical engineer. A *Student Solutions Manual* contains detailed solutions for over 100 selected end-of-the-chapter homework problems. For the selected problems that have computer solutions, MATLAB solution files are available for downloading from the Web. To download the *Student Solutions Manual* and the MATLAB files, go to [www.pearsonhighered.com/couch](http://www.pearsonhighered.com/couch).

One major change for this eighth edition is the addition of more than 100 examples distributed throughout the chapters of the text. Students are always asking for more examples. Most of these new examples have a problem description that consists of only a few lines of text. The solutions for these examples are contained within MATLAB files (downloaded from the Web site given earlier). These files include the procedure for the solution (as described by comment lines in the MATLAB program) and produce computed and plotted solutions. This presentation procedure has several advantages. First, the description for each example takes only a few lines

in this textbook, so the book will not be extended in length. Second, the student will have the experience of learning to work with MATLAB (as demonstrated with the example solutions). Clearly plotted results, which are better than hand calculations, are given. The student can also vary the parameters in the MATLAB example to discover how the results will be affected. The author believes that this approach to examples is a great innovative teaching tool.

To learn about communication systems, it is essential to first understand *how communication systems work*. Based on the principles of communications that are covered in the first five chapters of this book (power, frequency spectra, and Fourier analysis), this understanding is motivated by the use of extensive examples, study-aid problems, and the inclusion of adopted standards. Especially interesting is the material on wire and wireless communication systems. Also of importance is the effect of noise on these systems, since, without noise (described by probability and random processes), one could communicate to the limits of the universe with negligible transmitted power. In summary, this book covers the essentials needed for the understanding of wire and wireless communication systems and includes adopted standards. These essentials are

- How communication systems work: Chapters 1 through 5.
- The effect of noise: Chapters 6 and 7.
- Wire and Wireless Communication Applications: Chapter 8.

This book is ideal for either a one-semester or a two-semester course. This book emphasizes basic material and applications that can be covered in a one-semester course, as well as the essential material that should be covered for a two-semester course. This emphasis means that the page count needs to be limited to around 750 pages. For a book with a larger page count, it is impossible to cover all that additional material, even in a two-semester course. (Many schools are moving toward one basic course offering in communications.) Topics such as, coding, wireless signal propagation, WiMAX, and Long Term Evolution (LTE) of cellular systems are covered in this book. In-depth coverage of important topics such as these should be done by additional courses with their own textbooks.

For a one-semester course, the basics of how communication systems work may be taught by using the first five chapters (with selected readings from Chapter 8). For a two-semester course, the whole book is used.

This book covers *practical aspects* of communication systems developed from a sound *theoretical basis*.

## THE THEORETICAL BASIS

- Digital and analog signals
- Magnitude and phase spectra
- Fourier analysis
- Orthogonal function theory
- Power spectral density
- Linear systems
- Nonlinear systems
- Intersymbol interference
- Complex envelopes
- Modulation theory
- Probability and random processes
- Matched filters
- Calculation of SNR
- Calculation of BER
- Optimum systems
- Block and convolutional codes


## THE PRACTICAL APPLICATIONS

- PAM, PCM, DPCM, DM, PWM, and PPM baseband signaling
- OOK, BPSK, QPSK, MPSK, MSK, OFDM, and QAM bandpass digital signaling
- AM, DSB-SC, SSB, VSB, PM, and FM bandpass analog signaling
- Time-division multiplexing and the standards used
- Digital line codes and spectra
- Circuits used in communication systems
- Bit, frame, and carrier synchronizers
- Software radios
- Frequency-division multiplexing and the standards used
- Telecommunication systems
- Telephone systems
- DSL modems
- Digital subscriber lines
- Satellite communication systems
- Satellite radio broadcasting systems
- Effective input-noise temperature and noise figure
- Link budget analysis
- SNR at the output of analog communication systems
- BER for digital communication systems
- Fiber-optic systems
- Spread-spectrum systems
- AMPS, GSM, iDEN, TDMA, CDMA, WiMAX, and LTE cellular telephone systems
- Digital and analog television systems
- Technical standards for AM, FM, TV, DTV, and CATV
- Cable data modems
- Wi-Fi and WiMAX wireless networks
- MATLAB M files on the Web
- Mathematical tables
- Study-aid examples
- Over 100 examples with solutions. About 80 of these examples include MATLAB solutions
- Over 550 homework problems with selected answers
- Over 60 computer-solution homework problems
- Extensive references
- Emphasis on the design of communication systems
- *Student Solutions Manual* (download)

## WHAT'S NEW IN THIS EDITION

- Addition of over 100 examples with solutions that are distributed throughout the chapters of the book. Most of them have MATLAB computer solutions obtained via electronic M files which are downloaded free-of-charge from author's Web site.
- Includes up-to-date descriptions of popular wireless systems, LTE (long-term evolution) and WiMax 4G cellular systems, and personal communication applications.
- Includes latest updates on digital TV (DTV) technology.
- Brings terminology and standards up-to-date.
- Brings references up-to-date.
- Updates all chapters.

- Includes additional and revised homework problems.
- Includes suggestions for obtaining the latest information on applications and standards by using the appropriate keyword queries on internet search engines, such as Google.
- Continues the emphasis on MATLAB computer solutions to problems. This approach of using computer solutions is very important in training new communication engineers. This is one of the very few books that includes the actual electronic files for MATLAB solutions (available for free downloading from the internet). This is done so that the reader does not have to spend days in error-prone typing of lines of computer code that are listed in a textbook.
- Updates all MATLAB files to run on Version R2010b.
- Extends list of Answers to Selected Problems at the end of the book, with MATLAB solutions if appropriate.

Many of the homework problems are marked with a personal computer symbol, . This indicates that MATLAB computer solutions are available for this problem.

Homework problems are found at the end of each chapter. Complete solutions for those marked with a ★, approximately 1/3, are found in the *Student Solutions Manual*, available for free download at [www.pearsonhighered.com/couch](http://www.pearsonhighered.com/couch). Student M-files are also available for download. Complete solutions for all problems, including the computer solution problems, are given in the *Instructor Solutions Manual* (available only to instructors from Pearson/Prentice Hall). These manuals include Acrobat pdf files for the written solutions. Also, for the problems with computer solutions, MATLAB M files are given. Instructor's should contact their local Pearson rep for access.

This book is an outgrowth of my teaching at the University of Florida and is tempered by my experiences as an amateur radio operator (K4GWQ). I believe that the reader will not understand the technical material unless he or she works some homework problems. Consequently, over 550 problems have been included. Some of them are easy, so that the beginning student will not become frustrated, and some are difficult enough to challenge the more advanced students. All of the problems are designed to provoke thought about, and understanding of, communication systems.

I appreciate the help of the many people who have contributed to this book and the very helpful comments that have been provided by the many reviewers over the years. In particular, I thank K. R. Rao, University of Texas, Arlington; Jitendra J. Tugnait, Auburn University; John F. McDonald, Rensselaer Polytechnic Institute; Bruce A. Ferguson, Rose-Hulman Institute of Technology; Ladimer S. Nagurney, University of Hartford; Jeffrey Carruthers, Boston University; and Hen-Geul Yeh, California State University, Long Beach. I also appreciate the help of my colleagues at the University of Florida. I thank my wife, Dr. Margaret Couch, who typed the original and revised manuscripts and has proofread all page proofs.

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