

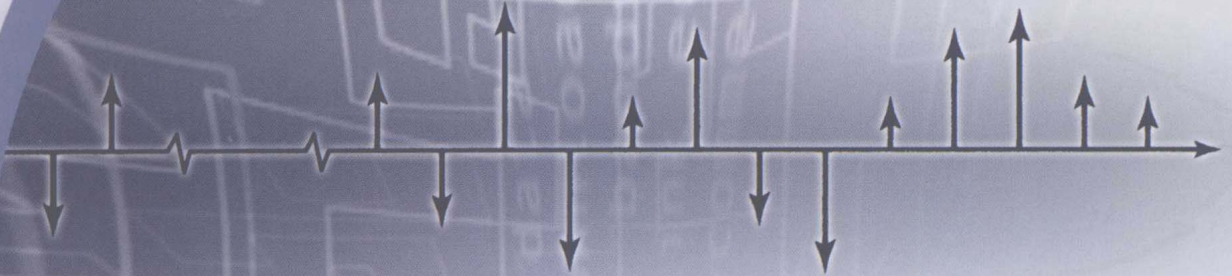
国外电子与通信教材系列

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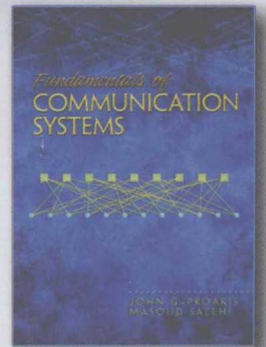
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通信系统原理



Fundamentals of Communication Systems



[美] John G. Proakis
Masoud Salehi

著

樊昌信 改编



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国外电子与通信教材系列

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(英文版)

Fundamentals of Communication Systems

[美] John G. Proakis 著

Masoud Salehi 著

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内 容 简 介

本书由西安电子科技大学樊昌信教授改编,与原书的不同在于去掉了最后两章(关于信息论及可靠通信编码)的内容。该书全面阐述了现代通信系统分析和设计所必需的基本原理,并对重要的数学基础知识进行了回顾。涉及的内容包括信号与线性系统、幅度调制、角度调制、噪音对模拟通信系统的影响、模数转换、AWGN 基带信道中的数字调制、带限 AWGN 信道中的数字传输、通过载波调制进行数字信息传输等。全书提供了许多实例以突出所述理论的工程应用,各章还配有大量难度不等的习题,以及一些计算机练习,以帮助读者检验并巩固所学的内容。

本书适合作为电子、通信相关专业高年级本科生和低年级研究生的通信系统课程教材,对于工程技术人员和自学人员也是非常有用的读本。

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序

2001年7月间,电子工业出版社的领导同志邀请各高校十几位通信领域方面的老师,商量引进国外教材问题。与会同志对出版社提出的计划十分赞同,大家认为,这对我国通信事业、特别是对高等院校通信学科的教学工作会很有好处。

教材建设是高校教学建设的主要内容之一。编写、出版一本好的教材,意味着开设了一门好的课程,甚至可能预示着一个崭新学科的诞生。20世纪40年代MIT林肯实验室出版的一套28本雷达丛书,对近代电子学科、特别是对雷达技术的推动作用,就是一个很好的例子。

我国领导部门对教材建设一直非常重视。20世纪80年代,在原教委教材编审委员会的领导下,汇集了高等院校几百位富有教学经验的专家,编写、出版了一大批教材;很多院校还根据学校的特点和需要,陆续编写了大量的讲义和参考书。这些教材对高校的教学工作发挥了极好的作用。近年来,随着教学改革不断深入和科学技术的飞速进步,有的教材内容已比较陈旧、落后,难以适应教学的要求,特别是在电子学和通信技术发展神速、可以讲是日新月异的今天,如何适应这种情况,更是一个必须认真考虑的问题。解决这个问题,除了依靠高校的老教师和专家撰写新的符合要求的教科书外,引进和出版一些国外优秀电子与通信教材,尤其是有选择地引进一批英文原版教材,是会有好处的。

一年多来,电子工业出版社为此做了很多工作。他们成立了一个“国外电子与通信教材系列”项目组,选派了富有经验的业务骨干负责有关工作,收集了230余种通信教材和参考书的详细资料,调来了100余种原版教材样书,依靠由20余位专家组成的出版委员会,从中精选了40多种,内容丰富,覆盖了电路理论与应用、信号与系统、数字信号处理、微电子、通信系统、电磁场与微波等方面,既可作为通信专业本科生和研究生的教学用书,也可作为有关专业人员的参考材料。此外,这批教材,有的翻译为中文,还有部分教材直接影印出版,以供教师用英语直接授课。希望这些教材的引进和出版对高校通信教学和教材改革能起一定作用。

在这里,我还要感谢参加工作的各位教授、专家、老师与参加翻译、编辑和出版的同志们。各位专家认真负责、严谨细致、不辞辛劳、不怕琐碎和精益求精的态度,充分体现了中国教育工作者和出版工作者的良好美德。

随着我国经济建设的发展和科学技术的不断进步,对高校教学工作会不断提出新的要求和希望。我想,无论如何,要做好引进国外教材的工作,一定要联系我国的实际。教材和学术专著不同,既要注意科学性、学术性,也要重视可读性,要深入浅出,便于读者自学;引进的教材要适应高校教学改革的需要,针对目前一些教材内容较为陈旧的问题,有目的地引进一些先进的和正在发展中的交叉学科的参考书;要与国内出版的教材相配套,安排好出版英文原版教材和翻译教材的比例。我们努力使这套教材能尽量满足上述要求,希望它们能放在学生们的课桌上,发挥一定的作用。

最后,预祝“国外电子与通信教材系列”项目取得成功,为我国电子与通信教学和通信产业的发展培土施肥。也恳切希望读者能对这些书籍的不足之处、特别是翻译中存在的问题,提出意见和建议,以便再版时更正。



中国工程院院士、清华大学教授
“国外电子与通信教材系列”出版委员会主任

出版说明

进入21世纪以来,我国信息产业在生产和科研方面都大大加快了发展速度,并已成为国民经济发展的支柱产业之一。但是,与世界上其他信息产业发达的国家相比,我国在技术开发、教育培训等方面都还存在着较大的差距。特别是在加入WTO后的今天,我国信息产业面临着国外竞争对手的严峻挑战。

作为我国信息产业的专业科技出版社,我们始终关注着全球电子信息技术的发展方向,始终把引进国外优秀电子与通信信息技术教材和专业书籍放在我们工作的重要位置上。在2000年至2001年间,我社先后从世界著名出版公司引进出版了40余种教材,形成了一套“国外计算机科学教材系列”,在全国高校以及科研部门中受到了欢迎和好评,得到了计算机领域的广大教师与科研工作者的充分肯定。

引进和出版一些国外优秀电子与通信教材,尤其是有选择地引进一批英文原版教材,将有助于我国信息产业培养具有国际竞争能力的技术人才,也将有助于我国国内在电子与通信教学工作中掌握和跟踪国际发展水平。根据国内信息产业的现状、教育部《关于“十五”期间普通高等教育教材建设与改革的意见》的指示精神以及高等院校老师们反映的各种意见,我们决定引进“国外电子与通信教材系列”,并随后开展了大量准备工作。此次引进的国外电子与通信教材均来自国际著名出版商,其中影印教材约占一半。教材内容涉及的学科方向包括电路理论与应用、信号与系统、数字信号处理、微电子、通信系统、电磁场与微波等,其中既有本科专业课程教材,也有研究生课程教材,以适应不同院系、不同专业、不同层次的师生对教材的需求,广大师生可自由选择 and 自由组合使用。我们还将与国外出版商一起,陆续推出一些教材的教学支持资料,为授课教师提供帮助。

此外,“国外电子与通信教材系列”的引进和出版工作得到了教育部高等教育司的大力支持和帮助,其中的部分引进教材已通过“教育部高等学校电子信息科学与工程类专业教学指导委员会”的审核,并得到教育部高等教育司的批准,纳入了“教育部高等教育司推荐——国外优秀信息科学与技术系列教学用书”。

为做好该系列教材的翻译工作,我们聘请了清华大学、北京大学、北京邮电大学、南京邮电大学、东南大学、西安交通大学、天津大学、西安电子科技大学、电子科技大学、中山大学、哈尔滨工业大学、西南交通大学等著名高校的教授和骨干教师参与教材的翻译和审校工作。许多教授在国内电子与通信专业领域享有较高的声望,具有丰富的教学经验,他们的渊博学识从根本上保证了教材的翻译质量和专业学术方面的严格与准确。我们在此对他们的辛勤工作与贡献表示衷心的感谢。此外,对于编辑的选择,我们达到了专业对口;对于从英文原书中发现的错误,我们通过与作者联络、从网上下载勘误表等方式,逐一进行了修订;同时,我们对审校、排版、印制质量进行了严格把关。

今后,我们将进一步加强同各高校教师的密切关系,努力引进更多的国外优秀教材和教学参考书,为我国电子与通信教材达到世界先进水平而努力。由于我们对国内外电子与通信教育的发展仍存在一些认识上的不足,在选题、翻译、出版等方面的工作中还有许多需要改进的地方,恳请广大师生和读者提出批评及建议。

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Preface

This book is intended as a senior level undergraduate textbook on communication systems for Electrical Engineering majors. Its primary objective is to introduce the basic techniques used in modern communication systems and to provide fundamental tools and methodologies used in the analysis and design of these systems. Although the book is mainly written as an undergraduate level textbook, it can be equally be useful to the practicing engineer, or as a self study tool.

The emphasis of the book is on digital communication systems, which are treated in detail in Chapters 7 through 11. These systems are the backbone of modern communication systems, including new generations of wireless communication systems, satellite communications, and data transmission networks. Traditional analog communication systems are also covered with due detail in Chapters 3, 4, and 6. In addition, the book provides detailed coverage of the background required for the course in two chapters, one on linear system analysis with emphasis on the frequency domain approach and Fourier techniques, and one on probability, random variables, and random processes. Although these topics are now covered in separate courses in the majority of electrical engineering colloquia, it is the experience of the authors that the students frequently need to review these topics in a course on communications, and therefore it is essential to have quick access the relevant material from these courses.

It is assumed that the students taking this course have background in calculus, linear algebra, basic electronic circuits, linear system theory, and probability and random variables. These latter two topics are reviewed in two chapters of the book.

ORGANIZATION OF THE BOOK

The book starts with a brief review of communication systems in Chapter 1 followed by methods of signal representation and system analysis in both time and frequency domains in Chapter 2. Emphasis is placed on the Fourier series and the Fourier transform representation of signals and the use of transforms in linear systems analysis.

Chapters 3 and 4 cover the modulation and demodulation of analog signals. In Chapter 3 amplitude modulation (AM), and in Chapter 4 frequency modulation (FM), and phase modulation (PM) are covered. Radio and television broadcasting and analog mobile radio cellular communication systems are also treated in these chapters.

In Chapter 5, we present a review of the basic definitions and concepts in probability and random processes. Special emphasis is placed on Gaussian random processes, which provide mathematically tractable models for additive noise disturbances. Both time domain and frequency domain representations of random signals are presented.

Chapter 6 covers the effects of additive noise in the demodulation of amplitude modulated (AM) and angle modulated (FM, PM) analog signals and a comparison of these analog signal modulations in terms of their signal-to-noise ratio performance. Also discussed in this chapter is the problem of estimating the carrier phase using a phase-locked loop (PLL). Finally, we describe the characterization of thermal noise and the effect of transmission losses in analog communication systems.

Chapter 7 is devoted to analog-to-digital conversion. Sampling theorem and quantization techniques are treated first, followed by waveform encoding methods including PCM, DPCM, and DM. This chapter concludes with brief discussion of LPC speech coding and the JPEG standard for image compression.

Chapter 8 treats modulation methods for baseband AWGN channels. Various types of binary and non-binary modulation methods are described based on a geometric representation of signals and their performance is evaluated in terms of the probability of error. The final topic of this chapter is focused on signal synchronization methods for digital communication systems.

In Chapter 9, we consider the problem of digital communication through bandlimited, AWGN channels. The effect of channel distortion on the transmitted signals is characterized in terms of intersymbol interference (ISI) and the design of adaptive equalizers for suppressing ISI is described.

Digital signal transmission via carrier modulation is described in Chapter 10. The carrier modulation methods treated in this chapter are pulse amplitude modulation (PAM), phase-shift keying (PSK), quadrature-amplitude modulation (QAM), frequency-shift keying (FSK), and continuous-phase frequency-shift keying (CPFSK).

A number of selected topics in digital communications are treated in Chapter 11. Topics include digital communication in fading multipath channels, multicarrier modulation (orthogonal frequency-division multiplexing), spread spectrum signals and systems, a brief description of the GSM and IS95 digital cellular communication systems, and link budget analysis in free space (line-of-sight) channels.

Throughout the book many worked examples are provided to emphasize the use of the techniques developed in theory. Each chapter follows with a large number of

problems at different levels of difficulty. The problems in each chapter are followed by a selection of computer problems which usually ask for simulation of various algorithms developed in that chapter using MATLAB. The solutions to the MATLAB problems are made available on the PH website for the book.

COURSE OPTIONS

This book can serve as a text in either a one-semester or a two-semester course in communication systems. An important consideration in the design of the course is whether or not the students have had a prior course in probability and random processes. Another important consideration is whether or not analog modulation and demodulation techniques are to be covered. Below, we outline three scenarios. Others are certainly possible.

1. A one-term course in analog and digital communication: Selected review sections from Chapters 2 and 5, all of Chapters 3, 4, 6, 7, and 8, and selections from Chapters 7–11.
2. A one-term course in digital communication: Selected review sections from Chapters 2 and 5, and Chapters 7–11.
3. A two-term course sequence on analog and digital communications:
 - Chapters 2–6 for the first course.
 - Chapters 7–11 for the second course.

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Introduction

Every day, in our work and in our leisure time, we use and come in contact with a variety of modern communication systems and communication media, the most common being the telephone, radio, and television. Through these media, we are able to communicate (nearly) instantaneously with people on different continents, transact our daily business, and receive information about various developments and noteworthy events that occur all around the world. Electronic mail and facsimile transmission have made it possible to rapidly communicate written messages across great distances.

Can you imagine a world without telephones, radios, and televisions? Yet, when you think about it, most of these modern communication systems were invented and developed during the past century. Here, we present a brief historical review of major developments within the last two hundred years that have had a major role in the development of modern communication systems.

1.1 HISTORICAL REVIEW

Telegraphy and Telephony

One of the earliest inventions of major significance to communications was the invention of the electric battery by Alessandro Volta in 1799. This invention made it possible for Samuel Morse to develop the electric telegraph, which he demonstrated in 1837. The first telegraph line linked Washington with Baltimore and became operational in May 1844. Morse devised the variable-length binary code given in Table 1.1, in which letters of the English alphabet were represented by a sequence of dots and dashes (code words). In this code, more frequently occurring letters are represented by short code words, while less frequently occurring letters are represented by longer code words.