

国外电子与通信教材系列

无线通信 调制与编码

Modulation and Coding for Wireless Communications

英文版

[英] Alister Burr 著

Prentice
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北京·BEIJING

内 容 简 介

调制与编码是通信工程中日益重要的两个相关课题。本书是关于调制与编码的权威教材,适用于选修高级通信工程课程的本科生以及无线通信领域的工程技术人员。本书尽可能使用图解方式来帮助读者理解抽象的概念,同时引入工程实例来演示和说明理论性原理。

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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,除了依靠高校的老师 and 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单位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、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谨与准确。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。

电子工业出版社

Abbreviations

3-RC	3 (symbol period) raised cosine (continuous phase modulation)
8-AMPM	8-state amplitude and phase modulation
8-PSK	8-state phase-shift keying
16-PSK	16-state phase-shift keying
16-QAM	16-state quadrature amplitude modulation
32-AMPM	32-state amplitude and phase modulation
32-CROSS	32-state cross-shaped (modulation constellation)
64-QAM	64-state quadrature amplitude modulation
256-QAM	256-state quadrature amplitude modulation
a.c.f.	auto correlation function
ACG	asymptotic coding gain
ACI	adjacent channel interference
ACS	add, compare, select (operations)
ADC	analog to digital conversion
ADSL	asymmetric digital subscriber line
AM-AM	amplitude modulation to amplitude modulation
AMP	amplitude modulated pulses
AM-PM	amplitude modulation to phase modulation
AMPM	amplitude and phase modulation
ASIC	application-specific integrated circuit
ASK	amplitude-shift keying
AWGN	additive white Gaussian noise
BCC	body-centred cubic (lattice)
BCH	Bose-Chaudhuri-Hocquenghem
BCJR	Bahl-Cocke-Jelinek-Raviv
BCM	block coded modulation
BER	bit error ratio
BPSK	binary phase-shift keying
BT	time-bandwidth product
BU	bad urban (COST 207 mobile channel model)
C-M	carrier-to-multipath ratio
CCI	co-channel interference
CCITT	Consultative Committee on International Telecommunications
CCSDS	Consultative Committee on Space Data Systems
CD	compact disk

Abbreviations

CDMA	code division multiple access
COFDM	coded orthogonal frequency division multiplexing
COST 207	COllaboration in Science and Technology – European research programme responsible for mobile channel models
CP-FSK	continuous phase frequency-shift keying
CPM	continuous phase modulation
CSI	channel-state information
DAB	digital audio broadcast
DBPSK	differential binary phase-shift keying
DECT	digitally enhanced cordless telecommunications
DFE	decision-feedback equalization
DFT	discrete Fourier transform
DPSK	differential phase-shift keying
DQPSK	differential quadrature phase-shift keying
DSL	digital subscriber line
DSP	digital signal processing
DVB	digital video broadcast
DVB-T	digital video broadcasting (terrestrial)
EGC	equal gain combining
ETSI	European Telecommunication Standards Institute
FDMA	frequency division multiple access
FEC	forward error correction
FIR	finite impulse response
FM	frequency modulation
FPGA	field programmable gate array
FSK	frequency-shift keying
FSM	finite state machine
GF	Galois field
GMSK	Gaussian minimum-shift keying
GSM	global system for mobile communications
GWSSUS	Gaussian wide-sense stationary uncorrelated scatterers
HF	high frequency
HPA	high power amplifier
HT	hilly terrain (COST 207 mobile channel model)
i.c.i.	inter-channel interference
i.s.i.	inter-symbol interference
IDFT	inverse discrete Fourier transform
IF	intermediate frequency
IIR	infinite impulse response
IMT-2000	international mobile telecommunications 2000
I/Q	in-phase and quadrature (modulator/demodulator)
IS-54	Interim Standard 54 (American second generation mobile standard)

IS-136	Interim Standard 136 (American second generation mobile standard)
ITU-T	International Telecommunications Union – Telecommunications
JPL	Jet Propulsion Laboratory
LCM	least common multiple
LLC	logical link control
LLR	log likelihood ratio
LNA	low noise amplifier
LO	local oscillator
LSB	least significant bit
MAC	medium access control
MAP	maximum a posteriori
<i>M</i> -FSK	<i>M</i> -ary frequency-shift keying
ML	maximum likelihood
ML-TCM	multilevel turbo-coded modulation
MLCM	multilevel coded modulation
MLSD	maximum likelihood sequence detection
MLSE	maximum likelihood sequence estimation
MMSE	minimum mean-square error
MPEG	Motion Picture Experts Group (coded video standard)
<i>M</i> -PSK	<i>M</i> -ary phase-shift keying
MRC	maximum ratio combining
MSB	most significant bit
MSK	minimum-shift keying
NASA	North American Space Administration
OFDM	orthogonal frequency division multiplexing
OQPSK	offset quadrature phase-shift keying
OSI	open systems interconnect
p.d.f.	probability density function
p.s.d.	power spectral density
$\pi/4$ QPSK	pi-by-4 quadrature phase-shift keying
PACS-UB	Personal Access Communication System – Unlicensed Band (American second generation mobile/cordless standard)
PC-RSC	parallel concatenated recursive-systematic convolutional codes
PCTCM	version of trellis turbo-coded modulation
PD	phase detector
PLL	phase-locked loop
PMR	private mobile radio
QAM	quadrature amplitude modulation
QPSK	quadrature phase-shift keying

Abbreviations

r.m.s.	root mean square
RA	rural area (COST 207 mobile channel model)
RAKE	spread spectrum receiver (not an acronym)
RF	radio frequency
RM	Reed–Muller
RPE-LPC	regular pulse excited linear predictive coding
RS	Reed–Solomon
RSC	recursive-systematic convolutional
RSSE	reduced-state sequence estimation
RS-TCM	recursive-systematic turbo-coded modulation
RX	receiver
S-random	spread random
SC	switched (or selection) combining
SEP	symbol error probability
SFH	slow frequency hopping
SFN	single frequency network
SISO	soft in, soft out
SNR	signal-to-noise ratio
SOVA	soft output Viterbi algorithm
SPC	single parity check
STAR-QAM	star quadrature amplitude modulation
TCM	trellis coded modulation
TDMA	time division multiple access
TETRA	terrestrial trunked radio
TFM	tamed frequency modulation
TOI	third-order intercept
T-TCM	turbo trellis coded modulation
TU	typical urban (COST 207 mobile channel model)
TWT	travelling wave tube
TX	transmitter
UHF	ultra high frequency (i.e. 300 MHz–3 GHz)
UMTS	universal mobile telecommunications system
V.32, V.32(bis), V.34	ITU-T voiceband modem standards
VCC	voltage-controlled clock
VCO	voltage-controlled oscillator
WER	word error ratio
WLAN	wireless local area networks
XOR	exclusive-OR (logic function)
ZF	zero-forcing

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Wireless communications has become one of the most rapidly growing industries in the world, and its products are now exerting an impact in all our lives. This is most obvious in the form of the mobile phone; but many other advances, such as digital broadcasting and the 'wireless Internet', will very soon be making their influence felt. In the developing world, wireless communications is also bringing telecommunications to millions (and potentially to billions) who have never yet made a telephone call. This book concerns one of the most fundamental aspects of wireless, or radio communications: the modulation and coding schemes that enable information to be transmitted over the radio channel.

Our purpose in this first chapter is to set the scene for the remainder of the book. We begin in Section 1.1 by placing modulation and coding in the context of a complete radio communication system, outlining its rôle in the transmitter and receiver, and its position in the open systems interconnect (OSI) model, which is often used to describe telecommunication systems. We also show that coding and modulation, although traditionally regarded as separate functions, should actually be treated jointly. We then, in Section 1.2, consider the parameters by which the performance of a modulation and coding scheme can be assessed, and how they impact on the performance of the communication system as a whole. This gives us the tools that will be used to assess the performance of schemes in the following chapters. The most important of these parameters are bandwidth and power requirements, upon which we focus in Section 1.3. This leads to a description in Section 1.4 of the system-level advantages which can result from improvements in modulation and