国外电子与通信教材系列

射频与微波电子学

Radio Frequency and Microwave Electronics Illustrated

英文版

[美] Matthew M. Radmanesh 著

PH PTR

電子工業出版社
Publishing House of Electronics Industry
www.phei.com.cn

国外电子与通信教材系列

射频与微波电子学

（英文版）

Radio Frequency and Microwave Electronics Illustrated

［美］Matthew M. Radmanesh 著

電子工業出版社
Publishing House of Electronics Industry
北京 · BEIJING

内容简介

本书为读者提供了有关射频与微波电路的基本概念、微波电子学以及高频电子线路设计原理等方面的基础知识。书中运用了大量的图解和实例，完整地讲解了电波传播、线性电路阻抗匹配、微波线性放大器以及在微波集成器件中非线性有源电路的设计等。

本书可以作为电子与通信专业的高年级本科生及研究生的教材，也可以作为从事射频电路和微波电路设计的工程技术人员的参考书。

版权贸易合同登记号：图字：01-2002-3808

图书在版编目（CIP）数据

射频与微波电子学（英文版）/（美）拉德马内斯（Radmanesh, M. M.）著.
-北京：电子工业出版社，2002.8
（国外电子与通信教材系列）
书名原文：Radio Frequency and Microwave Electronics Illustrated
ISBN 7-5053-7628-4
Ⅰ.射… Ⅱ.拉… Ⅲ.①射频电路-高等学校-教材-英文 ②微波电路-高等学校 Ⅳ. TN710

中国版本图书馆CIP数据核字（2002）第059228号

责任编辑：冯小贝
印 刷 者：北京市增富印刷有限责任公司
出版发行：电子工业出版社 http://www.phei.com.cn
北京市海淀区万寿路173信箱 邮编：100036
经 销：各地新华书店
开 本：787 × 980 1/16 印张：55 字数：1267千字
版 次：2002年8月第1版 2002年8月第1次印刷
定 价：79.00元（含光盘）

凡购买电子工业出版社的图书，如有缺损问题，请向购买书店调换。若书店售缺，请与本社发行部联系。联系电话：（010）68279077

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。

吴佑寿

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和自由组合使用。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。

电子工业出版社

教材出版委员会

主　任	吴佑寿	中国工程院院士、清华大学教授
副主任	林金桐	北京邮电大学校长、教授、博士生导师
	杨千里	总参通信部副部长、中国电子学会会士、副理事长 中国通信学会常务理事
委　员	林孝康	清华大学教授、博士生导师、电子工程系副主任、通信与微波研究所所长 教育部电子信息科学与工程类专业教学指导委员会委员
	徐安士	北京大学教授、博士生导师、电子学系副主任 教育部电子信息与电气学科教学指导委员会委员
	樊昌信	西安电子科技大学教授、博士生导师 中国通信学会理事、IEEE 会士
	程时昕	东南大学教授、博士生导师 移动通信国家重点实验室主任
	郁道银	天津大学副校长、教授、博士生导师 教育部电子信息科学与工程类专业教学指导委员会委员
	阮秋琦	北方交通大学教授、博士生导师 计算机与信息技术学院院长、信息科学研究所所长
	张晓林	北京航空航天大学教授、博士生导师、电子工程系主任 教育部电子信息科学与电气信息类基础课程教学指导委员会委员
	郑宝玉	南京邮电学院副院长、教授、博士生导师 教育部电子信息与电气学科教学指导委员会委员
	朱世华	西安交通大学教授、博士生导师、电子与信息工程学院院长 教育部电子信息科学与工程类专业教学指导委员会委员
	彭启琮	电子科技大学教授、博士生导师、通信与信息工程学院院长 教育部电子信息科学与电气信息类基础课程教学指导委员会委员
	徐重阳	华中科技大学教授、博士生导师、电子科学与技术系主任 教育部电子信息科学与工程类专业教学指导委员会委员
	毛军发	上海交通大学教授、博士生导师、电子信息学院副院长 教育部电子信息与电气学科教学指导委员会委员
	赵尔沅	北京邮电大学教授、教材建设委员会主任
	钟允若	原邮电科学研究院副院长、总工程师
	刘　彩	中国通信学会副理事长、秘书长
	杜振民	电子工业出版社副社长

About the Author

MATTHEW M. RADMANESH received his MSEE and Ph.D. degrees from the University of Michigan at Ann Arbor. He has taught at GMI Engineering & Management (presently Kettering University) and has worked in the RF and Microwave industry for Hughes Aircraft Co., Maury Microwave Corp., and Boeing Aircraft Co. He is currently a faculty member in the Electrical and Computer Engineering department at California State University, Northridge, CA. He is a senior member of IEEE, Eta Kappa Nu Honor Society, and a Past President (for three years) of the SFV Chapter of the IEEE Microwave Theory and Technique (MTT) Society. His many years of experience in both microwave industry and academia has led to several dozen technical papers in national and international journals. His current research interests include design of RF and microwave devices and circuits, millimeter-wave circuit applications, integrated optics, and engineering education. He received the distinguished lecturer award at the 1994 IEEE International Microwave Symposium and was awarded twice by IEEE LA Concil for his contributions to the MTT society (1994, 1995). Dr. Radmanesh won the MPD divisional award while at Hughes Aircraft Co. and a similar award from Boeing Aircraft Co. He holds two patents for his pioneering work and novel designs of two millimeter-wave noise sources.

Foreword

The field of RF and Microwaves has undergone a significant paradigm shift in the last decade. From being a technology that had its greatest utilization in defense and military-based applications, it is currently in the forefront as a fundamental technology in Wireless Communications and other industrial, medical, and commercial applications. As applications of RF and microwaves continue to evolve and as this technology becomes a common factor in the scientific and engineering communities it is imperative that university students and practicing scientists and engineers are thoroughly familiar with the measurement principles, electronics, and design fundamentals underlying this technology.

Several books on RF and microwave technology have been published since the landmark research and development effort that went into the development of radar and related techniques during World War II. Perhaps the most noteworthy and seminal publication in this area was the MIT Radiation Laboratory series which still stands out as an example of a major contribution to the scientific and engineering communities by a consortium of some of the world's leading scientists and engineers and as a memorial to the unnamed hundreds and thousands of engineers and scientists who actually carried out the research and development work, the results of which were presented in this series. Since the publication of this series, numerous books on RF and microwave technology have been published. These books have accommodated the advancements in the field and have provided rigorous mathematical analysis underlying the fundamental scientific principles. While these books have served their purposes as university texts and reference guides for practitioners, there was a significant gap in the available literature that as yet remained to be addressed. There has existed a need for a textbook that, through the use of graphical illustrations, rather than rigorous mathematical analysis, serves as a foundational treatise for graduate students and practicing engineers and scientists. Dr. Radmanesh's book *Radio Frequency and Microwave Electronics Illustrated* is an attempt directed at bridging this gap.

The book is organized into 5 distinct parts comprised of 21 chapters. At the end of each chapter are a list of symbols, sets of problems to test the reader's comprehension of the subject matter presented in the chapter, and a list of references for further reading or investigating a particular topic in greater detail.

Part I is comprised of four chapters. Chapters 1 and 2 introduce the reader to the fundamental postulates and axioms of science and engineering and the basic concepts and laws in electrical and electronics engineering. The presentation of these series of postulates and axioms is extremely helpful, since it lays the foundation for any of the engineering sciences and is particularly noteworthy, in that it has never been presented in any scientific text on RF and microwaves. Chapters 3 and 4 discuss the basic circuit mathematics and low frequency concepts. In Chapter 3, the groundwork is laid for basic mathematical concepts including phasors, basic circuit elements, Ohm's law, and its generalized version, Kirchoff's voltage and current laws, basic network theorems, and decibel scale. Chapter 4 introduces the reader to the behavior of the transistor circuits at DC and low frequencies. Even though microwave transistors are built differently and have a higher frequency range of operation, analysis of transistor circuits at DC and low frequencies provides a sound foundation for analysis and design of transistor circuits at RF and microwave frequencies.

Part II (Chapters 5–8) introduces the reader to the concept of wave propagation via basic concepts of Radio Frequency (RF) and microwave (MW) and their applications (Chapter 5), RF electronic concepts (Chapter 6), and fundamental concepts in wave propagation (Chapter 7). Chapter 8 is devoted strictly to RF/Microwave device and circuit characterization. Building on the concepts and fundamentals provided in previous chapters, Chapter 8 discusses the concepts of a two-port network. The reader is introduced to the characterization of two-part networks and its representation in terms of a set of parameters that can be cast into a matrix form.

Part III (Chapters 9–11) leads the reader to impedance matching concepts and passive circuit design. In Chapter 9, the "Smith Chart" (one of the most valuable and pervasive graphical tools in all of microwave engineering) is presented to the reader. The chart, as a reflection coefficient-to-impedance/admittance converter or vice versa, is discussed together with its ability to simplify the analysis of complex design problems involving transmission lines or lumped elements. Chapter 10 discusses the applications of the Smith Chart in three distinct categories: a) circuits containing primarily distributed elements, particularly transmission lines (TLs), b) circuits containing lumped elements, and c) circuits containing distributed and lumped elements in combination. Having developed a deep understanding of the Smith Chart and its applications, the reader is now introduced to the design of impedance matching networks in Chapter 11.

Part IV (Chapters 12–14) deals with the design considerations of microwave amplifiers. The chapters are systematically broken down to focus the reader on each of the important design parameters: stability concepts for a two-port network (Chapter 12), gain concepts in amplifiers (Chapter 13), and noise concepts in amplifier design (Chapter 14).

The readers conceptual journey is transformed to hard-core design examples of linear and nonlinear circuits and their applications in Part V (Chapters 15–21). The design examples include design of small-signal, narrow-band, low-noise, and multistage amplifiers (Chapter 15); design of large-signal, high-power amplifiers (Chapter 16); microwave transistor oscillator design, using the negative-resistance device concept in Chapter 17; microwave rectifier and detector design (Chapter 18); microwave mixer design (Chapter 19); and microwave control circuits, specifically

switches, phase shifters, and attenuators (Chapter 20). The book concludes with Chapter 21, which is devoted entirely to RF and Microwave Integrated Circuits (MICs). The two classes of microwave integrated circuits, i.e., hybrid microwave integrated circuits and monolithic microwave integrated circuits (MMIC), are discussed in detail addressing the materials, processing techniques, reliability, and advantages of each type.

A comprehensive glossary of technical terms at the end of the book is a great aid in understanding RF and Microwaves and makes this book invaluable for anyone aspiring to master this field of study. The appendix section provides a list of all symbols used in the book, information on many physical constants, mathematical identities, and generally known laws and makes them sufficiently accessible for easy reference. The Computer-Aided design (CAD) examples provide actual design data and methodology, which the reader should find extremely helpful in many practical situations.

In summary, this book has some unique strengths which make it different from prior literature and an attractive reference for the reader.

1. The presentation of a series of scientific postulates and axioms at the start of the book lays the foundation for any of the engineering sciences and is unique to this book compared with similar RF and Microwave texts.
2. The presentation of classical laws and principles of electricity and magnetism, all inter-related, conceptually and graphically.
3. There is a shift of emphasis from rigorous mathematical solutions of Maxwell's equations, and instead has been aptly placed on simple yet fundamental concepts that underlie these equations. This shift of emphasis will promote a deeper understanding of the electronics, particularly at RF/Microwave frequencies.
4. Low-frequency electronics unlike most RF/Microwave texts has been amply treated, which makes an easy transition to RF/Microwave principles and prevents a gap of knowledge in the reader's mind.
5. New technical terms are precisely defined as they are first introduced, thereby keeping the subject matter in focus and preventing misunderstanding, and finally the abundant use of graphical illustrations and diagrams brings a great deal of clarity and conceptual understanding, enabling difficult concepts to be understood with ease.

I believe Dr. Radmanesh has addressed the literature gap that I discussed during the introduction of this foreword and has presented some unique aspects, which I believe the graduate student, the practicing engineer/scientist, and the university professor should find extremely beneficial and stimulating. The book should serve as a valuable readable reference for the RF and Microwave industry.

Dr. Asad M. Madni
C. Eng., Fellow IEEE, Fellow IEE, FIAE, FNYAS
President and Chief Operating Officer
BEI Technologies, Inc.

Preface

Education in the science of RF and microwave engineering consists of guiding the reader along a gradient of known data, with the highest attention to the basic concepts that form the foundation of this field of study. The basic concepts presented in this book are far more fundamental than the mother sciences of engineering (i.e., physics and mathematics) and cover the essential truth about our physical universe in which we live. These basic truths convey a much deeper understanding about the nature of the physical universe than has ever been discussed in any RF and microwave, or for that matter any scientific textbook.

These basic truths set up a background of discovered knowledge by mankind, against which a smaller sphere of information (i.e., RF and microwave engineering) can be examined. Many of the principles that appear in microwave books are easily describable and thus understood much better once the basic underlying concepts are grasped.

While studying sciences and engineering at the university, the author always looked for simplicity, a higher truth, and a deeper level of understanding in all of the rigorous mathematics and many of the physical laws that were presented. Upon further investigation, the underlying principles that form the backbone of all extant physical sciences have finally emerged and are presented as the fundamentals of physical sciences in Chapter 1 of this work.

A summary of philosophical formation of this work is presented in the form of a pyramid in Chapter 1. From this pyramid, we can see that workable knowledge is like a pyramid, where from a handful of common denominators efficiently expressed by a series of basic postulates, axioms, and natural laws, which form the foundation of a science, an almost innumerable number of devices, circuits, and systems can be thought up and developed. The plethora of the mass of devices, circuits, and systems generated is known as the application mass, which practically approaches infinity in sheer number. This is an important point to grasp, because the foundation portion never changes (a static) while the base area of the pyramid is an ever-changing and evolving arena (a kinetic) where this evolution is in terms of new implementation techniques and technologies.

Following this brief introduction, the fundamental laws and basic principles of electrical engineering, which most advanced textbooks take for granted, are discussed. The reason for their presentation at this early stage, is that in dealing with the subject

of RF and microwave engineering, it has been found that a lack of deeper understanding of these fundamentals leads to a shallow perspective and a lack of appreciation of electrical engineering basics, which will eventually lead to serious miscomprehension and misapplication of the subject.

This book is written with emphasis on fundamentals and for this reason all new technical terms are thoroughly defined in the body of the text as they are introduced. This novel approach is based upon the results obtained in recent investigations and research in the field of education, which has shown that the lack of (or the slightest uncertainty on) the definition of terms poses as one of the most formidable obstacles in the reader's mind in achieving full comprehension of the material. A series of uncomprehended or misunderstood technical terms will block one's road to total comprehension and mastery of the subject. This undesirable condition will eventually lead to a dislike and total abandonment of the subject.

The initial motivation was to bring the basics to the forefront and orient the reader in such a way that he or she can think with these fundamentals correctly. This eventually led to writing the first manuscript several years ago and then the final preparation of this book at present.

In preparing this book, the emphasis was shifted from rigorous and sophisticated mathematical solutions of Maxwell's equations and instead has been aptly placed on RF and microwave circuit analysis and design principles using simple concepts while emphasizing the basics all the way.

This book is intended to be used in a 2-semester course in microwave electronics engineering for senior-level or graduate students and should serve as an excellent reference guide for the practicing RF and microwave engineer in the field as well.

The current work starts from very general postulates, considerations and laws and, chapter by chapter, narrows the focus to very specific concepts and applications, culminating in the design of various RF and microwave circuits. The book, divided into five parts and 21 chapters, develops and presents these chapters with the progressive development of concepts following the same pattern as presented in the pyramid of knowledge in Chapter 1, which is:

Part I The Highest Fundamentals
Chapters 1–4 form the foundation of electronics.

Part II Wave Propagation in Networks
Chapters 5–8 present the basics of RF and Microwave science, wave propagation, and network characterization concepts.

Part III Passive Circuit Design
Chapters 9–11 deal with the Smith Chart and its numerous applications to matching circuits.

Part IV Basic Considerations in Active Networks
Chapters 12–14 discuss the basic considerations of circuit design.

Part V Active Networks: Linear and Nonlinear Design
Chapters 15–21 provide detailed analysis and design methodologies of linear and nonlinear active circuits.

A list of symbols used in each chapter and a series of problems are included at the end of each chapter to help the reader gain a fuller understanding of the presented materials. The book ends with a glossary of technical terms and several important appendixes. These appendixes cover physical constants and other important data needed in the analysis or design process, with one appendix fully devoted to several design examples of practical active circuits using computer-aided design techniques based on the "Libra/touchstone"® software Ver. 6.1 from HPEEsof.

ACKNOWLEDGMENTS

The author wishes to thank many generations of students who studied the first manuscript of this work and several of its revisions to bring the current work to its fruition. The author is grateful to Jeff Quin of Litton Guidance Center whose assistance in preparation of several segments of this book has been invaluable. Thanks are also due to Lyman Hayes of Hayes Associates, Ed Skochinsky of Edwards Air Force Base technical division, Oskar Ulloa of Peter Green design for graphic illustration, Chris Savage for many valuable discussions of graphical design and layout as well as numerous helpful suggestions throughout the entire work, and Kimo Watanaby and Chris Hollosy for using superb technical skills in programming all the numerical examples in Visual Basic in the Microsoft Excel® Window environment. Many thanks are also due to Bernard Goodwin, Prentice-Hall Chief editor/publisher for the valuable hints, advice, and brilliant guidance along the way, Anne Trowbridge (PTR) for excellent coordination, and to Dmitri Nerubenko, Greg deZarn-O'Hare (Benchmark Productions) on an expedient and well-organized job on the production of the final copy of the book.

The author also wishes to thank many of his colleagues, particularly Dr. Asad Madni (CEO/COO of BEI Technologies, Inc.), a valuable colleague and a great friend, Dr. E. S. Gillespie, Dr. Tom Mincer, Dr. Ramin Roosta, Tim Fox, and R. Burger (California State University, Northridge, CA), Harvey Endler (JPL), Phillip Arnold (HP), Dr. George Haddad and Dr. C. M. Chu (University of Michigan, Ann Arbor, MI), Dr. M. Torfeh, Dr. B. Salajekeh, Dr. H. Hizroglu and Dr. B. Guru (Kettering University, Flint, MI), Dr. Charles Alexander and Dr. M. E. Mokari (Ohio University, Athens, OH), who provided support and collegiality through the years.

Finally, my deep gratitude belongs to my wife, Jane Marie, my son, Jeremy William, for making life pleasant during this work, and to my parents, Mary and Dr. G.H. Radmanesh, for their love, encouragement, and unconditional support throughout my life.

Matthew M. Radmanesh, Ph.D.
California State University, Northridge,
Dept. of Electrical and Computer Engineering
18111 Nordhoff St., Northridge, CA 91330
November 2000

目录概览

第一部分　基础知识 …… 1
THE HIGHEST FUNDAMENTALS

第1章　科学和工程学的基本概念 …… 3
Fundamental Concepts of Science and Engineering

第2章　电学与电子工程学的基本概念 …… 39
Fundamental Concepts in Electrical and Electronics Engineering

第3章　理解电路所需的数学基础 …… 69
Mathematical Foundation for Understanding Circuits

第4章　DC和低频电路的概念 …… 109
DC and Low-Frequency Circuits Concepts

第二部分　波在网络中的传播 …… 165
WAVE PROPAGATION IN NETWORKS

第5章　射频和微波的基本概念与应用 …… 167
Introduction to Radio Frequency and Microwave Concepts and Applications

第6章　RF电子学概念 …… 193
RF Electronics Concepts

第7章　波传播中的基本概念 …… 243
Fundamental Concepts in Wave Propagation

第8章　二端口RF/微波网络的电路表示 …… 287
Circuit Representations of Two-Port RF/Microwave Networks

第三部分　无源电路设计 …… 321
PASSIVE CIRCUIT DESIGN

第 9 章　Smith 圆图 …… 323
The Smith Chart

第 10 章　Smith 圆图的应用 …… 339
Applications of The Smith Chart

第 11 章　匹配网络的设计 …… 387
Design of Matching Networks

第四部分　有源网络中需要考虑的事项 …… 423
BASIC CONSIDERATIONS IN ACTIVE NETWORKS

第 12 章　有源网络中的稳定性 …… 425
Stability Considerations in Active Networks

第 13 章　放大器中的增益 …… 443
Gain Considerations in Amplifiers

第 14 章　有源网络中的噪声 …… 465
Noise Considerations in Active Networks

第五部分　有源网络：线性和非线性设计 …… 491
ACTIVE NETWORKS: LINEAR AND NONLINEAR DESIGN

第 15 章　RF/微波放大器 I：小信号设计 …… 493
RF/Microwave Amplifiers I: Small-Signal Design

第 16 章　RF/微波放大器 II：大信号设计 …… 531
RF/Microwave Amplifiers II: Large-Signal Design

第 17 章　RF/微波振荡器的设计 …… 569
RF/Microwave Oscillator Design

第 18 章　RF/微波频率转换 I：整流器和检测器的设计 …… 595
RF/Microwave Frequency Conversion I: Rectifier and Detector Design

第 19 章　RF/微波频率转换 II：混频器的设计 …… 617
RF/Microwave Frequency Conversion II: Mixer Design

第 20 章 RF/微波控制电路的设计 …… 647
RF/Microwave Control Circuit Design

第 21 章 RF/微波集成电路的设计 …… 679
RF/Microwave Integrated Circuit Design

第六部分 附录 …… 705
APPENDICES

附录 A 符号和缩写列表 …… 707
List of Symbols & Abbreviations

附录 B 物理常量 …… 717
Physical Constants

附录 C 国际单位制（SI） …… 719
International System of Units (SI)

附录 D 单位字首 …… 721
Unit Prefixes

附录 E 希腊字母 …… 723
Greek Alphabet

附录 F 电学、磁学和电磁学的经典定律 …… 725
Classical Laws of Electricity, Magnetism and Electromagnetics

附录 G 材质常量和频段 …… 735
Materials Constants & Frequency Bands

附录 H 二端口网络参数的转换 …… 739
Conversion Among Two-Port Network Parameters

附录 I 晶体管 Y 参数的转换（三种组态：CE、CB、CC） …… 741
Conversion Among the Y-Parameters of a Transistor (Three Configurations: CE, CB, and CC)

附录 J 常用的数学公式 …… 743
Useful Mathematical Formulas

附录 K 有关 FET 的 DC 偏置网络 …… 751
DC Bias Networks for an FET

附录 L 计算机辅助设计（CAD）范例 …… 755
Computer Aided Design (CAD) Examples

附录 M 等增益和等噪声系数圆的推导 …… 789
Derivation of the Constant Gain and Noise Figure Circles

附录 N 关于软件 …… 791
About the Software

术语表 …… 795
Glossary of Technical Terms

索引 …… 825
Index