

国外电子与通信教材系列

英文版

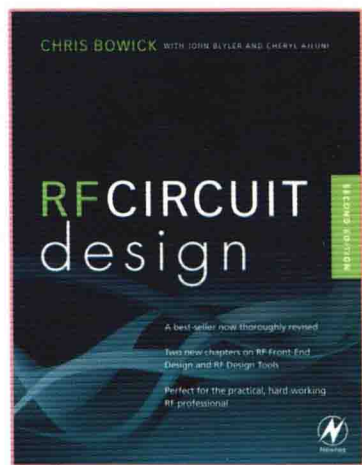


射频电路设计

(第二版)

RF Circuit Design
Second Edition

[美] Christopher Bowick 著
John Blyler
Cheryl Ajluni



 电子工业出版社
PUBLISHING HOUSE OF ELECTRONICS INDUSTRY

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北京·BEIJING

内 容 简 介

本书第一版写于1982年并多次重印,是一本经典的射频电路书籍。新版加强了无线技术方面的阐述,新增了关于射频前端设计与射频设计工具的两章内容,还包含了集成电路和系统级设计方面的内容。全书内容包括电路元件、谐振电路、滤波器设计、阻抗匹配、射频晶体管、小信号射频放大器设计、射频(大信号)功率放大器设计、射频前端电路设计和射频软件工具等。该书内容精炼,深入浅出,书中包括许多详细的设计实例,非常适合有一定电路基础的初学者作为实践指南。

本书适合射频与微波技术工程师、无线通信工程技术人员和通信网技术人员阅读,也可供相关科研工作者及工程技术人员参考。

RF Circuit Design, Second Edition

Christopher Bowick, John Blyler, Cheryl Ajluni

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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、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

A great deal has changed since Chris Bowick's *RF Circuit Design* was first published, some 25 years ago. In fact, we could just say that the RF industry has changed quite a bit since the days of Marconi and Tesla—both technological visionaries woven into the fabric of history as the men who enabled radio communications. Who could have envisioned that their innovations in the late 1800's would lay the groundwork for the eventual creation of the radio—a key component in all mobile and portable communications systems that exist today? Or, that their contributions would one day lead to such a compelling array of RF applications, ranging from radar to the cordless telephone and everything in between. Today, the radio stands as the backbone of the wireless industry. It is in virtually every wireless device, whether a cellular phone, measurement/instrumentation system used in manufacturing, satellite communications system, television or the WLAN.

Of course, back in the early 1980s when this book was first written, RF was generally seen as a defense/military technology. It was utilized in the United States weapons arsenal as well as for things like radar and anti-jamming devices. In 1985, that image of RF changed when the FCC essentially made several bands of wireless spectrum, the Industrial, Scientific, and Medical (ISM) bands, available to the public on a license-free basis. By doing so—and perhaps without even fully comprehending the momentum its actions would eventually create—the FCC planted the seeds of what would one day be a multibillion-dollar industry.

Today that industry is being driven not by aerospace and defense, but rather by the consumer demand for wireless applications that allow “anytime, anywhere” connectivity. And, it is being enabled by a range of new and emerging radio protocols such as Bluetooth®, Wi-Fi (802.11 WLAN), WiMAX, and ZigBee®, in addition to 3G and 4G cellular technologies like CDMA, EGPRS, GSM, and Long Term Evolution (LTE). For evidence of this fact, one needs look no further than the cellular handset. Within one decade, between roughly the years 1990 and 2000, this application emerged from a very small scale semiprofessional niche, to become an almost omnipresent device, with the number of users equal to 18% of the world population. Today, nearly 2 billion people use mobile phones on a daily basis—not just for their voice services, but for a growing number of social and mobile, data-centric Internet applications. Thanks to the mobile phone and service telecommunications industry revolution, average consumers today not only expect pervasive, ubiquitous mobility, they are demanding it.

But what will the future hold for the consumer RF application space? The answer to that question seems fairly well-defined as the RF industry now finds itself rallying behind a single goal: to realize true convergence. In other words, the future of the RF industry lies in its ability to enable next-generation mobile devices to cross all of the boundaries of the RF spectrum. Essentially then, this converged mobile device would bring together traditionally disparate functionality (e.g., mobile phone, television, PC and PDA) on the mobile platform.

Again, nowhere is the progress of the converged mobile device more apparent than with the cellular handset. It offers the ideal platform on which RF standards and technologies can converge to deliver a whole host of new functionality and capabilities that, as a society, we may not even yet be able to imagine. Movement in that direction has already begun. According to analysts with the IDC Worldwide Mobile Phone Tracker service, the converged mobile device market grew an estimated 42 percent in 2006 for a total of over 80 million units. In the fourth quarter alone, vendors shipped a total of 23.5 million devices, 33 percent more than the same quarter a year ago. That's a fairly remarkable accomplishment considering that, prior to the mid-nineties, the possibility of true RF convergence was thought unreachable. The mixing, sampling and direct-conversion technologies were simply deemed too clunky and limited to provide the foundation necessary for implementation of such a vision.

Regardless of how and when the goal of true convergence is finally realized, one thing has become imminently clear in the midst of all the growth and innovation of the past twenty five years—the RF industry is alive and well. More importantly, it is well primed for a future full of continuing innovation and market growth.

Of course, while all of these changes created a wealth of business opportunities in the RF industry, they also created new challenges for RF engineers pushing the limits of design further and further. Today, new opportunities signal new design challenges which engineers—whether experts in RF technology or not—will likely have to face.

One key challenge is how to accommodate the need for multi-band reception in cellular handsets. Another stems from the need for higher bandwidth at higher frequencies which, in turn, means that the critical dimensions of relevant parasitic elements shrink. As a result, layout elements that once could be ignored (e.g., interconnect, contact areas and holes, and bond pads) become non-negligible and influence circuit performance.

In response to these and other challenges, the electronics industry has innovated, and continues to innovate. Consider, for example, that roughly 25 years ago or so, electronic design automation (EDA) was just an infant industry, particularly for high-frequency RF and microwave engineering. While a few tools were commercially available, rather than use these solutions, most companies opted to develop their own high-frequency design tools. As the design process became more complex and the in-house tools too costly to develop and maintain, engineers turned to design automation to address their needs. Thanks to innovation from a variety of EDA companies, engineers now have access to a full gamut of RF/microwave EDA products and methodologies to aid them with everything from design and analysis to verification.

But the innovation doesn't stop there. RF front-end architectures have and will continue to evolve in step with cellular handsets sporting multi-band reception. Multi-band subsystems and shrinking element sizes have coupled with ongoing trends toward lower cost and decreasing time-to-market to create the need for tightly integrated RF front-ends and transceiver circuits. These high levels of system integration have in turn given rise to single-chip modules that incorporate front-end filters, amplifiers and mixes. But implementing single-chip RF front-end designs requires a balance of performance trade-offs between the interfacing subsystems, namely, the antenna and digital baseband systems. Achieving the required system performance when implementing integrated RF front-ends means that analog designers must now work more closely with their digital baseband counterpart, thus leading to greater integration of the traditional analog-digital design teams.

Other areas of innovation in the RF industry will come from improved RF power transistors that promise to give wireless infrastructure power amplifiers new levels of performance with better reliability and ruggedness. RFICs hope to extend the role of CMOS to enable emerging mobile handsets to deliver multimedia functions from a compact package at lower cost. Incumbents like gallium arsenide (GaAs) have moved to higher voltages to keep the pace going. Additionally, power amplifier-duplexer-filter modules will rapidly displace separate components in multi-band W-CDMA radios. Single-chip multimode transceivers will displace separate EDGE and W-CDMA/HSDPA transceivers in W-EDGE handsets. And, to better handle parasitic and high-speed effects on circuits, accurate modeling and back-annotation of ever-smaller layout elements will become critical, as will accurate electromagnetic (EM) modeling of RF on-chip structures like coils and interconnect.

Still further innovation will come from emerging technologies in RF such as gallium nitride and micro-electro-mechanical systems (MEMS). In the latter case, these advanced micromachined devices are being integrated with CMOS signal processing and conditioning circuits for high-volume markets such as mobile phones and portable electronics. According to market research firm ABI Research, by 2008 use of MEMs in mobile phones will take off. This is due to the technology's small size, flexibility and performance advantages, all of which are critical to enabling the adaptive, multifunction handsets of the future.

It is this type of innovation, coupled with the continuously changing landscape of existing application and market opportunities, which has prompted a renewed look at the content in *RF Circuit Design*. It quickly became clear that, in order for this book to continue to serve its purpose as your hands-on guide to RF circuit design, changes were required. As a result, this new 25th anniversary edition comes to you with updated information on existing topics like resonant circuits, impedance matching and RF amplifier design, as well as new content pertaining to RF front-end design and RF design tools. This information is applicable to any engineer working in today's dynamically changing RF industry, as well as for those true visionaries working on the cusp of the information/communication/entertainment market convergence which the RF industry now inspires.

Cheryl Ajluni and John Blyler

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