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

工程电路分析
（第六版）

Engineering Circuit Analysis, Sixth Edition

英文原版

William H. Hayt, Jr.
[美] Jack E. Kemmerly 著
Steven M. Durbin

McGraw Hill
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内容简介

这本英文原版教材是电路分析方面的一部经典著作，三位作者（其中两位已经过世）分别来自普渡大学、加利福尼亚州立大学和坎特伯雷大学。书中内容取材自作者在普渡大学、加利福尼亚州立大学、佛罗里达州立大学以及坎特伯雷大学的授课教材。本书从基本电路元件、电压电流定律等基本概念出发，介绍了节点和网孔分析、叠加原理和电源置换等常用分析方法。对于交流电路，也是从*RLC*电路的正弦稳态分析入手，然后讲解交流功率和磁耦合电路。为了适应现代发展趋势，作者充实了频域分析方面的内容，详细介绍了拉普拉斯变换和s域分析、频率响应和傅里叶分析、二端口网络等高级内容。作者力图将理论和实践相结合，提供了丰富的实例和数据。书中附有大量例题、练习和习题，书末附有单数习题答案。

本书可作为信息电子类、电气工程类和应用物理类本科生双语教学用的教材，也可供从事电子技术、电气工程方面工作的工程技术人员学习参考。

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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。

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ABOUT THE AUTHORS

William H. Hayt, Jr. received his B.S. and M.S. at Purdue University and his Ph.D. from the University of Illinois. After spending four years in industry, Professor Hayt joined the faculty of Purdue University, where he served as Professor and Head of the School of Electrical Engineering, and as Professor Emeritus after retiring in 1986. Besides *Engineering Circuit Analysis,* Professor Hayt authored three other texts, including *Engineering Electromagnetics,* now in its sixth edition with McGraw-Hill. Professor Hayt's professional society memberships included Eta Kappa Nu, Tau Beta Pi, Sigma Xi, Sigma Delta Chi, Fellow of IEEE, ASEE, and NAEB. While at Purdue, he received numerous teaching awards, including the university's Best Teacher Award. He is also listed in Purdue's Book of Great Teachers, a permanent wall display in the Purdue Memorial Union, dedicated on April 23, 1999. The book bears the names of the inaugural group of 225 faculty members, past and present, who have devoted their lives to excellence in teaching and scholarship. They were chosen by their students and their peers as Purdue's finest educators.

Jack E. Kemmerly received his B.S. magna cum laude from The Catholic University of America, M.S. from University of Denver, and Ph.D. from Purdue University. Professor Kemmerly first taught at Purdue University and later worked as principal engineer at the Aeronutronic Division of Ford Motor Company. He then joined California State University, Fullerton, where he served as Professor, Chairman of the Faculty of Electrical Engineering, Chairman of the Engineering Division, and Professor Emeritus. Professor Kemmerly's professional society memberships included Eta Kappa Nu, Tau Beta Pi, Sigma Xi, ASEE, and IEEE (Senior Member). His pursuits outside of academe included being an officer in the Little League and a scoutmaster in the Boy Scouts.

Steven M. Durbin received the B.S.E.E., M.S.E., and Ph.D. from Purdue University, West Lafayette, Indiana. After receiving the Ph.D., he joined the faculty of the Department of Electrical Engineering at Florida A&M University and The Florida State University. In August of 2000, he accepted a faculty position at the University of Canterbury, Christchurch, New Zealand, where he teaches circuits, electronics, and solid-state related courses, and conducts research into novel electronic materials and device structures. He is a member of Eta Kappa Nu, the IEEE, the Electron Devices Society, the American Physical Society, and the Royal Society of New Zealand.

PREFACE

Reading this book is intended to be an enjoyable experience, even though the text is by necessity scientifically rigorous and somewhat mathematical. We, the authors, are trying to share the idea that circuit analysis can be fun. Not only is it useful and downright essential to the study of engineering, it is a marvelous education in logical thinking, good even for those who may never analyze another circuit in their professional lifetime. Looking back after finishing the course, many students are truly amazed by all the excellent analytical tools that are derived from only three simple scientific laws—Ohm's law and Kirchhoff's voltage and current laws.

In many colleges and universities, the introductory course in electrical engineering will be preceded or accompanied by an introductory physics course in which the basic concepts of electricity and magnetism are introduced, most often from the field aspect. Such a background is not a prerequisite, however. Instead, several of the requisite basic concepts of electricity and magnetism are discussed (or reviewed) as needed. Only an introductory calculus course need be considered as a prerequisite—or possibly a co-requisite—to the reading of the book. Circuit elements are introduced and defined here in terms of their circuit equations; only incidental comments are offered about the pertinent field relationships. In the past, we have tried introducing the basic circuit analysis course with three or four weeks of electromagnetic field theory, so as to be able to define circuit elements more precisely in terms of Maxwell's equations. The results, especially in terms of students' acceptance, were not good.

We intend that this text be one from which students may teach the science of circuit analysis to themselves. It is written to the student, and not to the instructor, because the student is probably going to spend more time than the instructor in reading it. If at all possible, each new term is clearly defined when it is first introduced. The basic material appears toward the beginning of each chapter and is explained carefully and in detail; numerical examples are used to introduce and suggest general results. Practice problems appear throughout each chapter; they are generally simple, and answers to the several parts are given in order. The more difficult problems appear at the ends of the chapters and follow the general order of presentation of the text material. These problems are occasionally used to introduce less important or more advanced topics through a guided step-by-step procedure, as well as to introduce topics which will appear in the following chapter. The introduction and resulting repetition are both important to the learning process. In all, there are over 950 end-of-chapter problems in addition to numerous practice problems and worked examples. Most of the exercises are new in this edition, and, with the assistance of several colleagues, each problem was solved by hand and checked by computer when appropriate.

If the book occasionally appears to be informal, or even lighthearted, it is because we feel that it is not necessary to be dry or pompous to be educational. Amused smiles on the faces of our students are seldom obstacles to their absorbing information. If the writing of the text had its entertaining moments, then why not the reading too?

Much of the material in the text is based on courses taught at Purdue University; the California State University, Fullerton; Fort Lewis College in Durango; the joint engineering program of Florida A&M University and The Florida State University; and the University of Canterbury.

New in the Sixth Edition

Revising this text has been a daunting task, to say the very least. I used it as an undergraduate at Purdue University, where I was fortunate to take circuits from Professor Hayt himself—one of the best professors I ever had. In looking back, it's sometimes hard to remember how exactly I came to be invited to join the team of such a famous textbook. I met the sponsoring editor, Catherine Shultz, through my participation in the review of another textbook, and the fact that McGraw-Hill was planning to add a new co-author to *Engineering Circuit Analysis* eventually came up in conversation. She invited me to review the Fifth Edition, and summarize my thoughts as to where the Sixth Edition needed to go. That was back in March of 1999—and I've been working on this project ever since.

There are several very noteworthy features of *Engineering Circuit Analysis* that are responsible for its success. It is a very well structured book—key concepts are presented in a logical format, but also interlinked seamlessly into a larger framework. Bill Hayt and Jack Kemmerly put a great deal of work into the creation of the First Edition, and their desire to impart some of their boundless enthusiasm to the reader comes through in every chapter.

My first impressions were that not only did the figures need redrawing and updating, but that the numerous examples were often very difficult to locate. Also, the Fifth Edition relied very heavily upon the premise that students would work each and every Drill Problem; as such, Drill Problems were used as key vehicles to transfer concepts regarding methodology and basic problem-solving skills. Further, there was a need to inject more practical flavor into the text to capture the attention of today's students, to increase the number of examples, and to provide a larger assortment of end-of-chapter problems for instructors.

Each and every chapter in this book received careful attention. Some of the key changes users of the Fifth Edition will observe include:

1. A new introductory chapter has been written to provide students with a brief overview as well as key reasons for requiring them to study circuit analysis early in their program.
2. Chapter 1 has been split into two chapters, as has Chap. 2; this was done so that this important material could be introduced at a less rushed, more leisurely pace. The network topology material in Secs. 2.7 and 2.8 has been moved to an appendix.
3. In keeping with reviewer comments and the modern trend to reduce the amount of lecture time spent in time-domain analysis, the material in Chaps. 4 and 5 has been combined into a single chapter.

4. The material on op amps has been relocated from Chap. 1 to a self-contained chapter (Chap. 6). To the degree possible, the remainder of the text was written so that instructors who prefer to leave the teaching of op amp circuits to later electronics courses can do so without undue distraction. The common approach to op amps in circuit analysis textbooks is to attempt to use them as a "practical" application of dependent sources. This doesn't work perfectly, however, since almost as soon as we establish that model for op amps, we discard it in favor of the ideal op amp model. In this treatment, the ideal op amp is presented in the same way as the ideal resistor, capacitor, and inductor. Practical op amp analysis skills are emphasized in the introductory sections. Once the students develop some confidence with this eminently practical device, the ideal op amp model is derived from a more accurate (but nevertheless still approximate) dependent voltage source model.
5. Sinusoidal steady-state response concepts have been consolidated into a single chapter for a more streamlined approach.
6. A section on three-phase power measurement has been updated and reintroduced from an earlier version.
7. The chapter dealing with transformers has been relocated to immediately following the three-phase power chapter for the convenience of instructors.
8. Perhaps one of the largest reorganizations is the combination of the original treatment of complex frequency with the introduction to the Laplace transform. The modern trend has been to introduce Laplace transforms earlier in the course. However, students are almost always completely confounded when first confronted with the notion of a complex frequency, and so it was felt that a more gentle introduction to some of the related concepts was still appropriate.
9. Several new sections have been added, including discussions of how to choose from among the various circuit analysis techniques explained in the different chapters, and the design of filter circuits from a general perspective.
10. The chapter on state-variable analysis has been removed from the bound version of the text. However, depending on the interests of the instructor, this material can provide a useful perspective of general circuit analysis theory. For this reason, it was decided to make the original material available through the textbook website.
11. Over 300 new end-of-chapter problems have been added.
12. Practical Application sections have been added to many of the chapters, with the intention of showing how the many equations and theories presented apply to the real world.
13. PSpice® and MATLAB® examples have been added to almost every chapter. However, the authors feel strongly that computer-aided engineering should be just that—an aid, not a substitute for developing problem-solving skills. Thus, the introduction of computer tools has been carefully timed with the aid of many reviewer suggestions. Computer-aided analysis is introduced into homework problems only as the last part of a regular problem in order to encourage students to compare hand calculations to digital results. PSpice® student version 9.1 and MATLAB student version 5.0 were used.

14. The introduction to each chapter has been shortened, and now includes a Goals and Objectives section. Each chapter concludes with a short summary of key concepts to aid in review.
15. A series of margin icons has been introduced:

to indicate common errors;

highlights points to note carefully; and

indicates a design problem.

16. This edition of Engineering Circuit Analysis introduces a new multimedia supplement, *Virtual Professor.* Educators are slowly beginning to understand how different people learn in different fashions. For example, some students tend to be more visually oriented, while others are more audio-oriented. Others prefer to obtain the majority of their information directly from the written word. Accounting for variations in learning preferences, however, can be a daunting task in writing a textbook. The introductory set of eleven *Virtual Professor* modules has been developed as one means of combining the best of all worlds. Each module contains a narrated, animated mini-lecture on a particular introductory circuit analysis topic, along with one or more worked examples. The media player allows the module to be paused to allow notes to be taken, as well as to allow the student to attempt to finish an example before the solution is given. It also allows the user to replay a particular portion of any module as often as desired. The eleven modules are

Current, Voltage, and Power	Basic Mesh Analysis
Kirchhoff's Current Law	Advanced Mesh Analysis
Kirchhoff's Voltage Law	The Supermesh
Basic Nodal Analysis	Source Transformation
Advanced Nodal Analysis	Thévenin's Theorem
The Supernode	

One perspective, I suppose, is that the movie came out at the same time as the book!

The unexpected passing of Bill Hayt at the very beginning of this revision was an enormous shock. I never had the opportunity to talk to him about the intended changes—I can only hope that the revisions have helped this book to speak to yet another generation of bright young engineering students. In the meantime, we (durbin@ieee.org and the editors at McGraw-Hill) welcome comments and feedback from both students and instructors.

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steven m. durbin

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