国外电子电气经典教材系列

HZ BOOKS 华章教育

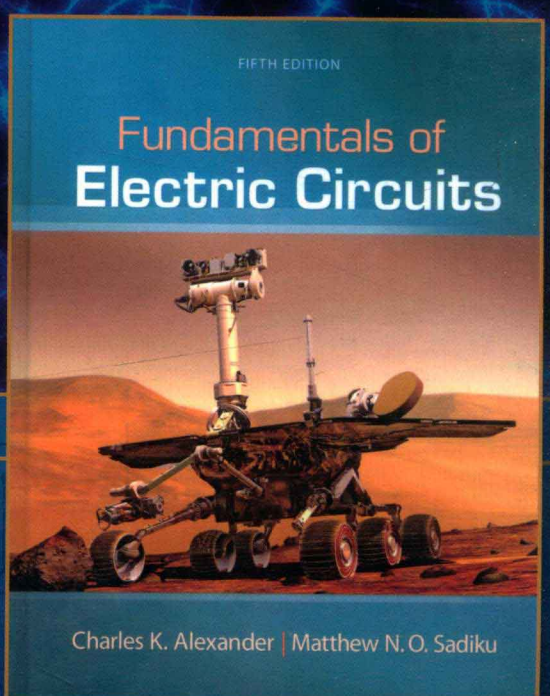
Mc Graw Hill Education

电路基础

(英文版·第5版)

Fundamentals of Electric Circuits (Fifth Edition)

[美] Charles K. Alexander
Matthew N. O. Sadiku 著 于歆杰 注释



机械工业出版社
China Machine Press

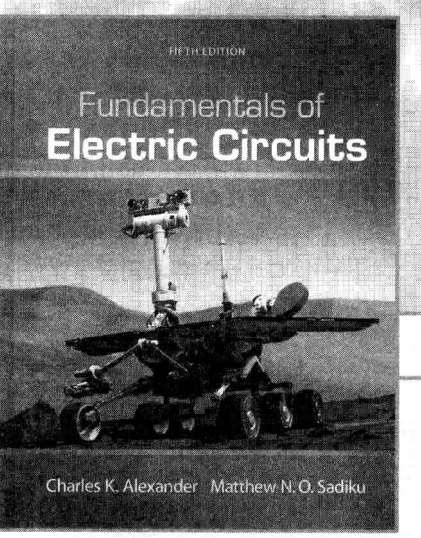
国外电子电气经典教材系列

电路基础

Fundamentals of Electric Circuits (Fifth Edition)

(英文版·第5版)

[美] Charles K. Alexander
Matthew N. O. Sadiku 著
于歆杰 注释



机械工业出版社
China Machine Press

图书在版编目（CIP）数据

电路基础（英文版·第5版）/（美）亚历山大等著. —北京：机械工业出版社，2013.2
（国外电子电气经典教材系列）
书名原文：Fundamentals of Electric Circuits, Fifth Edition

ISBN 978-7-111-41184-0

I. 电… II. 亚… III. 电路理论－教材－英文 IV. TM13

中国版本图书馆CIP数据核字（2013）第011742号

本书版权登记号：图字：01-2012-8918

机械工业出版社（北京市西城区百万庄大街22号 邮政编码 100037）
责任编辑：王 颖
北京诚信伟业印刷有限公司印刷
2013年2月第1版第1次印刷
186mm×240mm · 62印张
标准书号：ISBN 978-7-111-41184-0
定 价：129.00元

凡购本书，如有缺页、倒页、脱页，由本社发行部调换
客服热线：（010）88378991 88361066 投稿热线：（010）88379604
购书热线：（010）68326294 88379649 68995259 读者信箱：hzjsj@hzbook.com

出版者的话

文艺复兴以降，源远流长的科学精神和逐步形成的学术规范，使西方国家在自然科学的各个领域取得了垄断性的优势；也正是这样的传统，使美国在信息技术发展的六十多年间名家辈出、独领风骚。在商业化的进程中，美国的产业界与教育界越来越紧密地结合，信息学科中的许多泰山北斗同时身处科研和教学的最前线，由此而产生的经典科学著作，不仅擘划了研究的范畴，还揭示了学术的源变，既遵循学术规范，又自有学者个性，其价值并不会因年月的流逝而减退。

近年，在全球信息化大潮的推动下，我国的信息产业发展迅猛，对专业人才的需求日益迫切。这对我国教育界和出版界都既是机遇，也是挑战；而专业教材的建设在教育战略上显得举足轻重。在我国信息技术发展时间较短的现状下，美国等发达国家在其信息科学发展的几十年间积淀和发展的经典教材仍有许多值得借鉴之处。因此，引进一批国外优秀教材将对我国教育事业的发展起到积极的推动作用，也是与世界接轨、建设真正的世界一流大学的必由之路。

机械工业出版社华章公司较早意识到“出版要为教育服务”。自 1998 年开始，我们就将工作重点放在了遴选、移译国外优秀教材上。经过多年的不懈努力，我们与 Pearson，McGraw-Hill，John Wiley & Sons，Elsevier，Cambridge 等世界著名出版公司建立了良好的合作关系，从他们现有的数百种教材中甄选出《Digital Design: Principles and Practices，4E（数字设计原理与实践，原书第 4 版）》(John F.Wakerly 著）、《Fundamentals of Digital Logic with Verilog Design（数字逻辑基础与 Verilog 设计）》(Stephen Brown 著）、《Electromagnetic Field Theory Fundamentals，2E（电磁场与电磁波，原书第 2 版）》(Bhag Singh Guru 著）、《Fundamentals of Electric Circuits，5E(电路基础，原书第 5 版、英文版第 5 版)》(Charles K. Alexander 著）、《Digital Fundamentals: A Systems Approach（数字基础：系统方法）》(Thomas L. Floyd 著）、《Introductory Circuit Analysis ,12E（电路分析导论，原书第 12 版，本科教学版）》(Robert L.Boylestad 著）、《Foundations of MEMS，2E (微机电系统基础（原书第 2 版）》(Chang Liu 著）等大师名家的经典教材，以“国外电子电气经典教材系列”为总称出版，供读者学习、研究及珍藏。

权威的作者、经典的教材、一流的译者、严格的审校、精细的编辑，这些因素使我们的图书有了质量的保证。随着电子电气专业学科建设的不断完善和教材改革的逐渐深化，教育界对国外电子电气教材的需求和应用都将步入一个新的阶段，我们的目标是尽善尽美，而反馈的意见正是我们达到这一终极目标的重要帮助。华章公司欢迎老师和读者对我们的工作提出建议或给予指正，我们的联系方法如下：

华章网站：www.hzbook.com

电子邮件：hzjsj@hzbook.com

联系电话：(010) 88379604

联系地址：北京市西城区百万庄南街 1 号

邮政编码：100037

华章教育

华章科技图书出版中心

写在注释之前的话

Alexander 和 Sadiku 两位教授所著之《电路基础》是国内出版的最有影响力的美国电路课程教材之一。在美国，该教材也是发行量较大的教材之一，是 McGraw-Hill 公司在电路教材领域与其他公司进行竞争的核心产品。现在机械工业出版社购得其第 5 版的中文翻译版和双语版版权，得以及时反映该教材的最新进展，实为中国读者之幸事。

承蒙机械工业出版社华章分社计算机出版中心的信任，委托我做该书第 5 版双语版的注释工作并写作每章之前的导读，使我能够再次近距离接触世界高水平电路教材，作为一名电路课程教师来说，我不胜荣幸。恰逢此时我刚好在美国对 Purdue、UWM、UIUC、UC Berkeley 和 Stanford 大学进行访问，与其电路课程教师深入沟通和交流了课程的内容选择和教学法。利用访问的空闲时间，写下了对该书的一些体会。关于这本教材与其他当前流行教材的关系，请感兴趣的读者关注几位前辈带领我发表的一篇小文[1]。在此，我用简短的语言介绍一下当前这版书的特点。

（1）内容全面，涵盖了我国“电路分析基础”课程的全部教学要求和“电路理论基础”课程的大部分要求（缺均匀传输线和网络图论），适合用做中文电路课程的教材或参考书，或成为双语授课或全英文授课的教材。

（2）ABET 是美国工程与技术教育认证委员会的缩写。通过 ABET 认证的美国大学，和其他通过华盛顿协议缔约国认证的大学相比，在工程与技术人才培养方面，具有相同、可比的培养质量。这样就使得全世界工程技术人才的培养具有可比性，因此人才就能够顺利迁移。美国大多数名牌大学的工程专业都通过了 ABET 认证。ABET 对某个专业的认证过程是考察该专业培养方案中各门课程如何来培养学生的各种能力的[2]。在本书各章的“增强技能与拓展事业”部分，清晰地说明了如何将该章内容与 ABET 要求的能力联系起来。中国即将成为华盛顿协议缔约国，因此工程教育认证问题即将是未来几年工程教育领域的重头戏。各门课程（及其教材）都需要落实如何培养学生的各项能力。这本教材在明确学生能力培养方面值得借鉴。除了 ABET 要求的各项能力外，在“增强技能与拓展事业”部分还对电路课程与电气工程、电子工程、自动化、计算机等领域工程师需要具备的素质之间的关系进行了介绍，能够让学生通过本书的学习，尽早了解各个电类专业的侧重和热点。

（3）例题、习题的种类和数量巨大，能够给学生提供充分的训练机会。此外，作者还精心设计了 121 道设计型问题，有助于拔尖创新人才的培养。

（4）每章均至少有 1 个应用实例，实例取材精巧，写作通俗易懂，让读者明晰本章内容是如何应用在工程实际中的。当前，美国电路课程的教学思路是电路理论与工程实践相结合，让学生明白理论的伟大意义不在于解电路题，而在于解决工程实际问题。我国电路课程和电路教材也逐渐开始有这样的趋势。本书的出版对进一步提高我国电路课程教学质量应该有积极的促进作用。

如果将该书用于电路课程教学，则在内容方面有一些需要教师补充资料或删减的地方，列举如下：（a）对非线性电阻电路的介绍偏少，尤其是缺乏对小信号分析的讨论，这样就没法将电路课程与模拟电子电路课程进行顺畅过渡；（b）作者在第 3 章引出了双极型晶体管（BJT），但是并未在全书中普遍使用，这样就将对电路分析方法的讨论局限在 RLCM 和运算放大器电路中；（c）对一阶电路、二阶电路、正弦稳态电路和三相电路的讨论都太冗长，太拘泥于电路分析，没能及时总计一般性的分析方法。

中国的改革开放使得我们能够方便地阅读世界上优秀畅销的各种电路教材。纵观这些教材，虽然本书存在上述不足，但瑕不掩瑜，本书依然是众多国外电路教材之翘楚，是一本难得的经典教材和参考书。

需要说明，上述观点和每章导读中的意见仅为本人浅见，不当之处，恭请赐教。

于歆杰（yuxj@tsinghua.edu.cn）

2012 年 12 月于美国旧金山

1 龚绍文，郑君里，于歆杰.电路课程的历史、现状和前景[J].电气电子教学学报，33(6):5-12, 2011.

2 感兴趣的读者可参考http://www.abet.org/。

Preface

You may be wondering why we chose a photo of NASA's Mars Rover for the cover. We actually chose it for several reasons. Obviously, it is very exciting; in fact, space represents the most exciting frontier for the entire world! In addition, much of the Rover itself consists of all kinds of circuits. Circuits that must work without needing maintenance! Once you are on Mars, it is hard to find a technician!

The Rover must have a power system that can supply all the power necessary to move it, help it collect samples and analyze them, broadcast the results back to Earth, and receive instructions from Earth. One of the important issues that make the problem of working with the rover is that it takes about 20 minutes for communications to go from the Earth to Mars. So the Rover does not make changes required by NASA quickly.

What we find most amazing is that such a sophisticated and complicated electro-mechanical device can operate so accurately and reliably after flying millions of miles and being bounced onto the ground! Here is a link to an absolutely incredible video of what the Rover is all about and how it got to Mars: http://www.youtube.com/watch?v=5UmRx4dEdRI. Enjoy!

Features

New to This Edition

A model for magnetic coupling is presented in Chapter 13 that will make analysis easier as well as enhance your ability to find errors. We have successfully used this model for years and felt it was now time to add it to the book. In addition, there are over 600 new end-of-chapter problems, changed end-of-chapter problems, and changed practice problems.

We have also added National Instruments *Multisim*™ solutions for almost all of the problems solved using *PSpice*®. There is a *Multisim* tutorial available on our website. We have added National Instruments *Multisim* since it is very user-friendly with many more options for analysis than *PSpice*. In addition, it allows the ability to modify circuits easily in order to see how changing circuit parameters impacts voltages, currents, and power. We have also moved the tutorials for *PSpice, MATLAB*®, and *KCIDE* to our website to allow us to keep up with changes in the software.

We have also added 43 new problems to Chapter 16. We did this to enhance using the powerful s-domain analysis techniques to finding voltages and currents in circuits.

Retained from Previous Editions

A course in circuit analysis is perhaps the first exposure students have to electrical engineering. This is also a place where we can enhance some of the skills that they will later need as they learn how to design.

An important part of this book is our 121 ***design a problem*** problems. These problems were developed to enhance skills that are an important part of the design process. We know it is not possible to fully develop a student's design skills in a fundamental course like circuits. To fully develop design skills a student needs a design experience normally reserved for their senior year. This does not mean that some of those skills cannot be developed and exercised in a circuits course. The text already included open-ended questions that help students use creativity, which is an important part of learning how to design. We already have some questions that are open-ended but we desired to add much more into our text in this important area and have developed an approach to do just that. When we develop problems for the student to solve our goal is that in solving the problem the student learns more about the theory and the problem solving process. Why not have the students design problems like we do? That is exactly what we do in each chapter. Within the normal problem set, we have a set of problems where we ask the student to design a problem to help other students better understand an important concept. This has two very important results. The first will be a better understanding of the basic theory and the second will be the enhancement of some of the student's basic design skills. We are making effective use of the principle of learning by teaching. Essentially we all learn better when we teach a subject. Designing effective problems is a key part of the teaching process. Students should also be encouraged to develop problems, when appropriate, which have nice numbers and do not necessarily overemphasize complicated mathematical manipulations.

A very important advantage to our textbook, we have a total of 2,447 Examples, Practice Problems, Review Questions, and End-of-Chapter Problems! Answers are provided for all practice problems and the odd numbered end-of-chapter problems.

The main objective of the fifth edition of this book remains the same as the previous editions—to present circuit analysis in a manner that is clearer, more interesting, and easier to understand than other circuit textbooks, and to assist the student in beginning to see the "fun" in engineering. This objective is achieved in the following ways:

- **Chapter Openers and Summaries**
  Each chapter opens with a discussion about how to enhance skills which contribute to successful problem solving as well as successful careers or a career-oriented talk on a sub-discipline of electrical engineering. This is followed by an introduction that links the chapter with the previous chapters and states the chapter objectives. The chapter ends with a summary of key points and formulas.
- **Problem-Solving Methodology**
  Chapter 1 introduces a six-step method for solving circuit problems which is used consistently throughout the book and media supplements to promote best-practice problem-solving procedures.
- **Student-Friendly Writing Style**
  All principles are presented in a lucid, logical, step-by-step manner. As much as possible, we avoid wordiness and giving too much detail that could hide concepts and impede overall understanding of the material.

- **Boxed Formulas and Key Terms**
  Important formulas are boxed as a means of helping students sort out what is essential from what is not. Also, to ensure that students clearly understand the key elements of the subject matter, key terms are defined and highlighted.
- **Margin Notes**
  Marginal notes are used as a pedagogical aid. They serve multiple uses such as hints, cross-references, more exposition, warnings, reminders not to make some particular common mistakes, and problem-solving insights.
- **Worked Examples**
  Thoroughly worked examples are liberally given at the end of every section. The examples are regarded as a part of the text and are clearly explained without asking the reader to fill in missing steps. Thoroughly worked examples give students a good understanding of the solution process and the confidence to solve problems themselves. Some of the problems are solved in two or three different ways to facilitate a substantial comprehension of the subject material as well as a comparison of different approaches.
- **Practice Problems**
  To give students practice opportunity, each illustrative example is immediately followed by a practice problem with the answer. The student can follow the example step-by-step to aid in the solution of the practice problem without flipping pages or looking at the end of the book for answers. The practice problem is also intended to test a student's understanding of the preceding example. It will reinforce their grasp of the material before the student can move on to the next section. Complete solutions to the practice problems are available to students on the website.
- **Application Sections**
  The last section in each chapter is devoted to practical application aspects of the concepts covered in the chapter. The material covered in the chapter is applied to at least one or two practical problems or devices. This helps students see how the concepts are applied to real-life situations.
- **Review Questions**
  Ten review questions in the form of multiple-choice objective items are provided at the end of each chapter with answers. The review questions are intended to cover the little "tricks" that the examples and end-of-chapter problems may not cover. They serve as a self test device and help students determine how well they have mastered the chapter.
- **Computer Tools**
  In recognition of the requirements by ABET® on integrating computer tools, the use of *PSpice, Multisim, MATLAB, KCIDE for Circuits*, and developing design skills are encouraged in a student-friendly manner. *PSpice* is covered early on in the text so that students can become familiar and use it throughout the text. Tutorials on all of these are available on our website. *MATLAB* is also introduced early in the book.

- **Design a Problem Problems**
  Finally, *design a problem* problems are meant to help the student develop skills that will be needed in the design process.
- **Historical Tidbits**
  Historical sketches throughout the text provide profiles of important pioneers and events relevant to the study of electrical engineering.
- **Early Op Amp Discussion**
  The operational amplifier (op amp) as a basic element is introduced early in the text.
- **Fourier and Laplace Transforms Coverage**
  To ease the transition between the circuit course and signals and systems courses, Fourier and Laplace transforms are covered lucidly and thoroughly. The chapters are developed in a manner that the interested instructor can go from solutions of first-order circuits to Chapter 15. This then allows a very natural progression from Laplace to Fourier to AC.
- **Four Color Art Program**
  An interior design and four color art program bring circuit drawings to life and enhance key pedagogical elements throughout the text.
- **Extended Examples**
  Examples worked in detail according to the six-step problem solving method provide a roadmap for students to solve problems in a consistent fashion. At least one example in each chapter is developed in this manner.
- **EC 2000 Chapter Openers**
  Based on ABET's skill-based CRITERION 3, these chapter openers are devoted to discussions as to how students can acquire the skills that will lead to a significantly enhanced career as an engineer. Because these skills are so very important to the student while still in college as well after graduation, we use the heading, *"Enhancing your Skills and your Career."*
- **Homework Problems**
  There are 468 new or changed end-of-chapter problems which will provide students with plenty of practice as well as reinforce key concepts.
- **Homework Problem Icons**
  Icons are used to highlight problems that relate to engineering design as well as problems that can be solved using *PSpice, Multisim, KCIDE,* or *MATLAB.*

Organization

This book was written for a two-semester or three-quarter course in linear circuit analysis. The book may also be used for a one-semester course by a proper selection of chapters and sections by the instructor. It is broadly divided into three parts.

- Part 1, consisting of Chapters 1 to 8, is devoted to dc circuits. It covers the fundamental laws and theorems, circuits techniques, and passive and active elements.

- Part 2, which contains Chapter 9 to 14, deals with ac circuits. It introduces phasors, sinusoidal steady-state analysis, ac power, rms values, three-phase systems, and frequency response.
- Part 3, consisting of Chapters 15 to 19, are devoted to advanced techniques for network analysis. It provides students with a solid introduction to the Laplace transform, Fourier series, Fourier transform, and two-port network analysis.

The material in the three parts is more than sufficient for a two-semester course, so the instructor must select which chapters or sections to cover. Sections marked with the dagger sign (†) may be skipped, explained briefly, or assigned as homework. They can be omitted without loss of continuity. Each chapter has plenty of problems grouped according to the sections of the related material and diverse enough that the instructor can choose some as examples and assign some as homework. As stated earlier, we are using three icons with this edition. We are using  to denote problems that either require *PSpice* in the solution process, where the circuit complexity is such that *PSpice* or *Multisim* would make the solution process easier, and where *PSpice* or *Multisim* makes a good check to see if the problem has been solved correctly. We are using  to denote problems where *MATLAB* is required in the solution process, where *MATLAB* makes sense because of the problem makeup and its complexity, and where *MATLAB* makes a good check to see if the problem has been solved correctly. Finally, we use **e2d** to identify problems that help the student develop skills that are needed for engineering design. More difficult problems are marked with an asterisk (*).

Comprehensive problems follow the end-of-chapter problems. They are mostly applications problems that require skills learned from that particular chapter.

Prerequisites

As with most introductory circuit courses, the main prerequisites, for a course using this textbook, are physics and calculus. Although familiarity with complex numbers is helpful in the later part of the book, it is not required. A very important asset of this text is that ALL the mathematical equations and fundamentals of physics needed by the student, are included in the text.

Supplements

McGraw-Hill Connect® Engineering

McGraw-Hill Connect Engineering is a web-based assignment and assessment platform that gives students the means to better connect with their coursework, with their instructors, and with the important concepts that they will need to know for success now and in the future. With Connect Engineering, instructors can deliver assignments, quizzes, and tests easily online. Students can practice important skills at their own pace and on their own schedule. Ask your McGraw-Hill representative for more details and check it out at www.mcgrawhillconnect.com/engineering.

Instructor and Student Website

Available at www.mhhe.com/alexander are a number of additional instructor and student resources to accompany the text. These include complete solutions for all practice and end-of-chapter problems, solutions in *PSpice* and *Multisim* problems, lecture PowerPoints®, text image files, transition guides to instructors, Network Analysis Tutorials, FE Exam questions, flashcards, and primers for *PSpice, Multisim, MATLAB*, and *KCIDE*. The site also features COSMOS, a complete online solutions manual organization system that allows instructors to create custom homework, quizzes, and tests using end-of-chapter problems from the text.

Knowledge Capturing Integrated Design Environment for Circuits (*KCIDE for Circuits*)

This software, developed at Cleveland State University and funded by NASA, is designed to help the student work through a circuits problem in an organized manner using the six-step problem-solving methodology in the text. *KCIDE for Circuits* allows students to work a circuit problem in *PSpice* and *MATLAB*, track the evolution of their solution, and save a record of their process for future reference. In addition, the software automatically generates a Word document and/or a PowerPoint presentation. The software package can be downloaded for free.

It is hoped that the book and supplemental materials supply the instructor with all the pedagogical tools necessary to effectively present the material.

McGraw-Hill Create™

Craft your teaching resources to match the way you teach! With McGraw-Hill Create, www.mcgrawhillcreate.com, you can easily rearrange chapters, combine material from other content sources, and quickly upload content you have written like your course syllabus or teaching notes. Find the content you need in Create by searching through thousands of leading McGraw-Hill textbooks. Arrange your book to fit your teaching style. Create even allows you to personalize your book's appearance by selecting the cover and adding your name, school, and course information. Order a Create book and you'll receive a complimentary print review copy in three to five business days or a complimentary electronic review copy (eComp) via e-mail in minutes. Go to www.mcgrawhillcreate.com today and register to experience how McGraw-Hill Create empowers you to teach *your* students *your* way.

Acknowledgements

We would like to express our appreciation for the loving support we have received from our wives (Hannah and Kikelomo), daughters (Christina, Tamara, Jennifer, Motunrayo, Ann, and Joyce), son (Baixi), and our extended family members. We would like to additionally thank Baixi (now Dr. Baixi Su Alexander) for his assistance in checking problems for clarity and accuracy.

At McGraw-Hill, we would like to thank the following editorial and production staff: Raghu Srinivasan, publisher and senior sponsoring editor; Lora Kalb-Neyens, developmental editor; Curt Reynolds, marketing manager, Joyce Watters, project manager; and Margarite Reynolds, designer.

The fifth edition has benefited greatly from the many outstanding reviewers and symposium attendees who contributed to the success of the first four editions! In addition, the following have made important contributions to this edition (in alphabetical order):

Alok Berry, *George Mason University*
Vahe Caliskan, *University of Illinois-Chicago*
Archie Holmes, *University of Virginia*
Anton Kruger, *University of Iowa*
Arnost Neugroschel, *University of Florida*
Arun Ravindran, *University of North Carolina-Charlotte*

Finally, we appreciate the feedback received from instructors and students who used the previous editions. We want this to continue, so please keep sending us e-mails or direct them to the publisher. We can be reached at c.alexander@ieee.org for Charles Alexander and sadiku@ieee.org for Matthew Sadiku.

C. K. Alexander and M. N. O. Sadiku

A Note to the Student

This may be your first course in electrical engineering. Although electrical engineering is an exciting and challenging discipline, the course may intimidate you. This book was written to prevent that. A good textbook and a good professor are an advantage—but you are the one who does the learning. If you keep the following ideas in mind, you will do very well in this course.

- This course is the foundation on which most other courses in the electrical engineering curriculum rest. For this reason, put in as much effort as you can. Study the course regularly.
- Problem solving is an essential part of the learning process. Solve as many problems as you can. Begin by solving the practice problem following each example, and then proceed to the end-of-chapter problems. The best way to learn is to solve a lot of problems. An asterisk in front of a problem indicates a challenging problem.
- *Spice* and *Multisim*, computer circuit analysis programs, are used throughout the textbook. *PSpice*, the personal computer version of *Spice*, is the popular standard circuit analysis program at most universities. *PSpice for Windows* and *Multisim* are described on our website. Make an effort to learn *PSpice* and/or *Multisim*, because you can check any circuit problem with them and be sure you are handing in a correct problem solution.
- *MATLAB* is another software that is very useful in circuit analysis and other courses you will be taking. A brief tutorial on *MATLAB* can be found on our website. The best way to learn *MATLAB* is to start working with it once you know a few commands.
- Each chapter ends with a section on how the material covered in the chapter can be applied to real-life situations. The concepts in this section may be new and advanced to you. No doubt, you will learn more of the details in other courses. We are mainly interested in gaining a general familiarity with these ideas.
- Attempt the review questions at the end of each chapter. They will help you discover some "tricks" not revealed in class or in the textbook.
- Clearly a lot of effort has gone into making the technical details in this book easy to understand. It also contains all the mathematics and physics necessary to understand the theory and will be very useful in your other engineering courses. However, we have also focused on creating a reference for you to use both in school as well as when working in industry or seeking a graduate degree.
- It is very tempting to sell your book after you have completed your classroom experience; however, our advice to you is *DO NOT SELL YOUR ENGINEERING BOOKS!* Books have always been expensive; however, the cost of this book is virtually the same as I paid for my circuits text back in the early 60s in terms of real dollars. In

fact, it is actually cheaper. In addition, engineering books of the past are nowhere near as complete as what is available now.

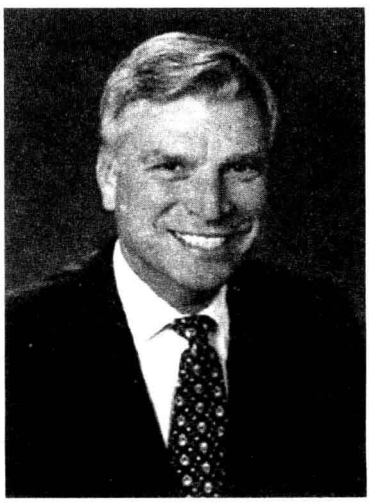
When I was a student, I did not sell any of my engineering textbooks and was very glad I did not! I found that I needed most of them throughout my career.

A short review on finding determinants is covered in Appendix A, complex numbers in Appendix B, and mathematical formulas in Appendix C. Answers to odd-numbered problems are given in Appendix D.

Have fun!

C. K. A. and M. N. O. S.

About the Authors



Charles K. Alexander

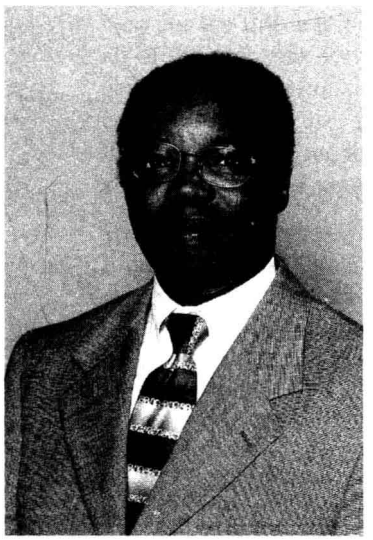
Charles K. Alexander is professor of electrical and computer engineering in the Fenn College of Engineering at Cleveland State University, Cleveland, Ohio. He is also the Director of The Center for Research in Electronics and Aerospace Technology (CREATE). From 2002 until 2006 he was Dean of the Fenn College of Engineering. From 2004 until 2007, he was Director of Ohio ICE, a research center in instrumentation, controls, electronics, and sensors (a coalition of CSU, Case, the University of Akron, and a number of Ohio industries). From 1998 until 2002, he was interim director (2000 and 2001) of the Institute for Corrosion and Multiphase Technologies and Stocker Visiting Professor of electrical engineering and computer science at Ohio University. From 1994–1996 he was dean of engineering and computer science at California State University, Northridge.

From 1989–1994 he was acting dean of the college of engineering at Temple University, and from 1986–1989 he was professor and chairman of the department of electrical engineering at Temple. From 1980–1986 he held the same positions at Tennessee Technological University. He was an associate professor and a professor of electrical engineering at Youngstown State University from 1972–1980, where he was named Distinguished Professor in 1977 in recognition of "outstanding teaching and research." He was assistant professor of electrical engineering at Ohio University in 1971–1972. He received honorary Dr. Eng. from Ohio Northern University (2009), the PhD (1971) and M.S.E.E. (1967) from Ohio University and the B.S.E.E. (1965) from Ohio Northern University.

Dr. Alexander has been a consultant to 23 companies and governmental organizations, including the Air Force and Navy and several law firms. He has received over $85 million in research and development funds for projects ranging from solar energy to software engineering. He has authored 40 publications, including a workbook and a videotape lecture series, and is coauthor of *Fundamentals of Electric Circuits*, *Problem Solving Made* Almost *Easy*, and the fifth edition of the *Standard Handbook of Electronic Engineering*, with McGraw-Hill. He has made more than 500 paper, professional, and technical presentations.

Dr. Alexander is a fellow of the IEEE and served as its president and CEO in 1997. In 1993 and 1994 he was IEEE vice president, professional activities, and chair of the United States Activities Board (USAB). In 1991–1992 he was region 2 director, serving on the Regional Activities Board (RAB) and USAB. He has also been a member of the Educational Activities Board. He served as chair of the USAB Member Activities Council and vice chair of the USAB Professional Activities Council for Engineers, and he chaired the RAB Student Activities Committee and the USAB Student Professional Awareness Committee.

In 1998 he received the Distinguished Engineering Education Achievement Award from the Engineering Council, and in 1996 he received the Distinguished Engineering Education Leadership Award from the same group. When he became a fellow of the IEEE in 1994, the citation read "for leadership in the field of engineering education and the professional development of engineering students." In 1984 he received the IEEE Centennial Medal, and in 1983 he received the IEEE/RAB Innovation Award, given to the IEEE member who best contributes to RAB's goals and objectives.



Matthew N. O. Sadiku

Matthew N. O. Sadiku is presently a professor at Prairie View A&M University. Prior to joining Prairie View, he taught at Florida Atlantic University, Boca Raton, and Temple University, Philadelphia. He has also worked for Lucent/Avaya and Boeing Satellite Systems.

Dr. Sadiku is the author of over 170 professional papers and almost 30 books including *Elements of Electromagnetics* (Oxford University Press, 3rd ed., 2001), *Numerical Techniques in Electromagnetics* (2nd ed., CRC Press, 2000), *Simulation of Local Area Networks* (with M. Ilyas, CRC Press, 1994), *Metropolitan Area Networks* (CRC Press, 1994), and *Fundamentals of Electric Circuits* (with C. K. Alexander, McGraw-Hill). His books are used worldwide, and some of them have been translated into Korean, Chinese, Italian, and Spanish. He was the recipient of the 2000 McGraw-Hill/Jacob Millman Award for outstanding contributions in the field of electrical engineering. He was the IEEE region 2 Student Activities Committee chairman and is an associate editor for IEEE "Transactions on Education." He received his PhD at Tennessee Technological University, Cookeville.

PRACTICAL APPLICATIONS

Each chapter devotes material to practical applications of the concepts covered in *Fundamentals of Electric Circuits* to help the reader apply the concepts to real-life situations. Here is a sampling of the practical applications found in the text:

- Rechargeable flashlight battery (Problem 1.11)
- Cost of operating toaster (Problem 1.25)
- Potentiometer (Section 2.8)
- Design a lighting system (Problem 2.61)
- Reading a voltmeter (Problem 2.66)
- Controlling speed of a motor (Problem 2.74)
- Electric pencil sharpener (Problem 2.79)
- Calculate voltage of transistor (Problem 3.86)
- Transducer modeling (Problem 4.87)
- Strain gauge (Problem 4.90)
- Wheatstone bridge (Problem 4.91)
- Design a six-bit DAC (Problem 5.83)
- Instrumentation amplifier (Problem 5.88)
- Design an analog computer circuit (Example 6.15)
- Design an op amp circuit (Problem 6.71)
- Design analog computer to solve differential equation (Problem 6.79)
- Electric power plant substation—capacitor bank (Problem 6.83)
- Electronic photo flash unit (Section 7.9)
- Automobile ignition circuit (Section 7.9)
- Welding machine (Problem 7.86)
- Airbag igniter (Problem 8.78)
- Electrical analog to bodily functions—study of convulsions (Problem 8.82)
- Electronic sensing device (Problem 9.87)
- Power transmission system (Problem 9.93)
- Design a Colpitts oscillator (Problem 10.94)
- Stereo amplifier circuit (Problem 13.85)
- Gyrator circuit (Problem 16.62)
- Calculate number of stations allowable in AM broadcast band (Problem 18.63)
- Voice signal—Nyquist rate (Problem 18.65)