



国外电气信息类优秀教材改编系列

Adapted Oversea Excellent Textbooks on Electrical Engineering

PEARSON

Prentice  
Hall

# 电路分析基础

第十版  
改编版

## Introductory Circuit Analysis 10/e

原著 Robert L. Boylestad

改编 陈希有 柴凤 孙立山



高等教育出版社  
Higher Education Press

国外电气信息类优秀教材改编系列  
Adapted Oversea Excellent Textbooks on Electrical Engineering

Introductory Circuit Analysis 10/e

# 电路分析基础

(第 10 版 改编版)

原著 Robert L. Boylestad  
改编 陈希有 柴凤 孙立山

江苏工业学院图书馆  
藏书章

高等教育出版社

图字:01-2004-6711 号

Original edition, entitled INTRODUCTORY CIRCUIT ANALYSIS, 10<sup>TH</sup> Edition by BOYLESTAD, ROBERT L., published by Pearson Education, Inc., publishing as Prentice-Hall, Copyright © 2003.

All right reserved. No part of this book may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording or by any information storage retrieval system, without permission from Pearson Education Inc.

China Adapted edition published by Pearson Education Asia Ltd. and Higher Education Press, Copyright © 2006

This Adapted edition is manufactured in the People's Republic of China, and is authorized for sale only in People's Republic of China (excluding Taiwan and the Special Administrative Regions of Hong Kong and Macao).

本书封面贴有 Pearson Education(培生教育出版集团)激光防伪标签。  
无标签者不得销售。

**For sale and distribution in the People's Republic of China exclusively  
(except Taiwan, Hong Kong SAR and Macao SAR).**

**仅限于中华人民共和国境内(但不允许在中国香港、澳门特别行政区和中国台湾地区)销售发行。**

**图书在版编目(CIP)数据**

电路分析基础 = Introductory Circuit Analysis:  
第 10 版:改编版/(美)博伊尔斯塔德(Boylestad, R.  
L.)著;陈希有,柴凤,孙立山改编. —北京:高  
等教育出版社, 2006.3

ISBN 7-04-018358-7

I. 电... II. ①博...②陈...③柴...④孙...  
III. 电路分析-高等学校-教材-英文 IV. TM133

中国版本图书馆 CIP 数据核字(2005)第 160878 号

|      |                |      |   |
|------|----------------|------|---|
| 出版发行 | 高等教育出版社        | 购书热线 | 010-58581118  |
| 社 址  | 北京市西城区德外大街 4 号 | 免费咨询 | 800-810-0598  |
| 邮政编码 | 100011         | 网 址  | <a href="http://www.hep.edu.cn">http://www.hep.edu.cn</a>         |
| 总 机  | 010-58581000   |      | <a href="http://www.hep.com.cn">http://www.hep.com.cn</a>         |
| 经 销  | 蓝色畅想图书发行有限公司   | 网上订购 | <a href="http://www.landaco.com">http://www.landaco.com</a>       |
| 印 刷  | 北京中科印刷有限公司     |      | <a href="http://www.landaco.com.cn">http://www.landaco.com.cn</a> |
|      |                | 畅想教育 | <a href="http://www.widedu.com">http://www.widedu.com</a>         |
| 开 本  | 787×960 1/16   | 版 次  | 2006 年 3 月第 1 版   |
| 印 张  | 90.5           | 印 次  | 2006 年 3 月第 1 次印刷   |
| 字 数  | 1 710 000      | 定 价  | 89.00 元   |

本书如有缺页、倒页、脱页等质量问题,请到所购图书销售部门联系调换。

版权所有 侵权必究

物料号 18358-00

---

**Copyright © 2003, 2000, 1997, 1994, 1990, 1987, 1982, 1977, 1972, 1968 by Pearson Education, Inc., Upper Saddle River, New Jersey 07458.** All rights reserved. Printed in the United States of America. This publication is protected by Copyright and permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department.



10 9 8 7 6 5 4 3 2

ISBN: 0-13-097417-X

## Library of Congress Cataloging-in-Publication Data

Boylestad, Robert L.

Introductory circuit analysis/Robert L. Boylestad. —10th ed.

p. cm.

Includes index.

ISBN 0-13-097417-X(alk. paper)

1. Electric circuits. 2. Electric circuit analysis—Data processing 3. PSpice. I. Title

TK454. B68 2003

621.319'2—dc21

2002019603

Editor in Chief: Stephen Helba

Acquisitions Editor: Dennis Williams

Associate Editor: Kate Linsner

Production Editor: Rex Davidson

Text Designer: Rebecca M. Bobb

Cover Art: Painting by Sigmund Årseth, artist and teacher, Valdres, Norway

Design Coordinator: Karrie Converse-Jones

Cover Designer: Thomas Mack

Production Manager: Patricia A. Tonneman

This book was set in Times Roman by The Clarinda Company and was printed and bound by R. R. Donnelley & Sons, Inc. The cover was printed by Phoenix Color Corp.

Cadence and the Cadence logo, Orcad, PSpice, and Orcad Capture are registered trademarks of Cadence Design Systems, Inc.

C++ is a product of Borland Software Corporation.

Electronics Workbench and Multisim are registered trademarks of Electronics Workbench, Inc.

Mathcad is a product of MathSoft Engineering & Education, Inc.

Pearson Education Ltd.

Pearson Education Australia Pty. Limited

Pearson Education Singapore Pte. Ltd.

Pearson Education North Asia Ltd.

Pearson Education Canada Ltd.

Pearson Educación de México, S. A. de C. V.

Pearson Education—Japan

Pearson Education Malaysia Pte. Ltd.

***To Else Marie***

***Alison, Mark, Kelcy, Morgan, and Cody***

***Eric, Rachel, and Samantha***

***Stacey, Jonathan, and Britt***

***Johanna***

# Preface

As I wrote the preface for this tenth edition of *Introductory Circuit Analysis*, it was impossible not to reflect over the past 34 years of its history. There were times when it was particularly difficult to be sure which subjects were outdated, whether a new topic should be added, whether a presentation was at the correct level or too mathematically complex, whether the computer coverage should be expanded, and so on. Fortunately, however, students' questions in class and in laboratory sessions, combined with comments from peers and reviewers, helped define the areas to be reworked and the subjects to be added. Nonetheless, in my desire to please everyone, the book grew in size to the point where I seriously considered dropping sections and even whole chapters. However, the reaction to such a change was so negative that it seemed that the best alternative was simply to accept the fact that any new material could be considered only if a similar amount of content was deleted.

It is always interesting that as I sit down to write the preface for one edition, I am already aware of changes that will appear in the next edition. For example, in the area of computers for this edition, I felt a strong need to maintain the detailed descriptions that appear with the applications of PSpice, Mathcad, and Electronics Workbench. However, the quality of the supporting literature has improved significantly in recent years, leading me to believe that most of the detail will be dropped from the eleventh edition, with possibly only the output files or printouts provided. One of the most enjoyable challenges for me with each new edition is to come up with something innovative that will support the learning process. In the ninth edition it was the addition of numerous practical examples, and in the eighth edition it was the detail to support the Windows version of PSpice. Going back to the fifth edition (1987), I can recall debating whether to introduce computer analysis to the text with the addition of BASIC programs. Obviously, it was the right move when we consid-

## II Preface

er the coverage that such analysis receives in most texts today. In another edition it was the expansion of the early chapter on mathematical operations, as I found that many students lacked the proper background for the work to follow. Revision is a continuing process that provides a wonderful challenge for future editions.

The most obvious changes for this edition are in the computer area. I was pleased with OrCAD's family release of the 9.2 Lite Edition, allowing me to move on from Version 8. I can recall when I finally became confident in the use of the DOS version of PSpice, and then the Windows version was introduced. I realized that although I had developed my skills in the DOS mode, I had to learn this new approach. At first I was reluctant and took pains to point out everything I didn't like about the Windows version. However, with exposure and time, I recognized that it was obviously the way of the future; and now, of course, I welcome the change. The same was true to some extent when I became familiar with Version 8 of PSpice and then Version 9 (under new ownership) was introduced with a number of changes. There was a period where I simply stayed with Version 8 rather than make the change. However, Cadence Design Systems has made a significant effort to soften the changes and bring back its close association with the MicroSim version. The time has come to move on to the new version. Most of the changes are in the front end and in some of the simulation sequences. Be assured, however, that if you are familiar with Version 8 and you take a few minutes to review the introductory material in this text, the new version will soon be as user-friendly as the old. In fact, you will probably appreciate some of the changes that were made.

For this edition the Multisim 2001 version of Electronics Workbench was added in response to its expanded use by a number of institutions. It has the distinct advantage of permitting the use of actual instruments to make the measurements, giving students a laboratory experience using the computer.

Finally, I decided to let Mathcad play an active role in the learning process. Students today are so quick to learn how to apply software packages that I felt the ability to perform complex mathematical operations with the computer would only entice students to become more familiar with computer methods. I can recall years ago when students would sit in awe when I showed them how to perform some basic operations with a computer. Today, I have to be constantly on my toes to keep up with the questions they ask, and, admittedly, I



sometimes have to do some research before I can answer them properly.

The coverage of C++ remains the same in response to positive comments from current users. However, with the addition of Electronics Workbench, and based on some comments received from reviewers, I decided to remove the BASIC programs and their descriptions.

Through recent years I have received numerous comments about the order of the last few chapters of the book. This time I took a close look at the content and decided that some of the recommended changes were valid and should be made. I must admit, however, that the new order is primarily a result of my own teaching experience and the order in which I feel the topics should be covered in an introductory text. The order of the numbered sections in Chapter 12 ("Inductors") was also changed to ensure that the most important topics were covered first and that the use of the general equation for transient behavior was presented earlier so that it could be used throughout the chapter.

Other noticeable changes include deletion of material surrounding the introduction of superconductors because the descriptions required a background beyond the students' current level. Also, the term *rms* is now used almost exclusively rather than *eff* as in past editions. In the description of phasor algebra, the letters **A**, **B**, and **C** were replaced by **X**, **Y**, and **Z** to provide a bridge between the mathematical operations and the network parameters. In Chapter 10 on capacitors, the general equation for transient behavior is introduced earlier to permit its use throughout the chapter. In fact, it is now used throughout Chapter 24 so that students do not have to refer to the basic defining equations presented earlier.

The CD-ROM enclosed with this textbook contains 96 circuit files provided in both Electronics Workbench Version 5 and Multisim, as well as an enhanced Textbook Edition of Multisim.

I am very pleased with the reaction to the extensive changes made in the last edition of the laboratory manual. I'm sure that the positive reaction was partially due to the fact that the standard protoboard can now be used to set up the circuits because of the change to  $\frac{1}{4}$ -W resistors. The new laboratory experiment on potentiometers was also a standout in the reviewers' comments. Minor changes were made, but in general the laboratory experiments are the same as in the last edition.

In addition to the Laboratory Manual, a full package of ancillaries accompa-

## IV Preface

nies this text, including:

Instructor's Solutions Manual

Test Item File

Prentice Hall Test Manager (electronic test bank)

PowerPoint® Transparencies CD-ROM

Instructor's Supplements CD-ROM

Blackboard

Course Compass

Companion Website <http://www.prenhall.com/boylestad>

As with every edition, a number of individuals were very helpful in developing the content for this edition. My sincerest thanks go to Jerry Sitbon for taking the time to respond to my many questions about everything under the sun and for helping me define the content for specific areas of the text. Professor Franz Monssen, with his extensive experience in computer software, was very helpful in developing the presentation of the new version of PSpice. For this edition, developmental editor Kate Linsner was particularly helpful in searching for specific information, keeping track of all the necessary details, and defining a clear channel toward completion of the text. A special thank you also goes to Sigmund Årseth for the special painting that graces the cover.

Throughout the years the production team in Columbus, Ohio, has been superb in every sense of the word. Rex Davidson, production editor and good friend, somehow removes all the stress from the production process. My editors, Scott Sambucci and Dennis Williams, are always there to help make important decisions and to do everything to ensure that the published text has all the elements necessary to make it a success. The ability of editorial assistant Lara Dimmick to take care of a mountain of details is deeply appreciated. My copy editor, Maggie Diehl, continues to amaze me with the questions asked and the suggestions offered to improve the text.

Finally, I want to thank all of you, the readers, for believing in the text through all these years. Writing and revising the text is an endeavor that has provided a wonderful range of satisfaction and pleasure that I hope will continue in the future. There is nothing I enjoy more than hearing from current users of the text, and perhaps from those of some nine editions ago. I assure you that any communication will not go unanswered. My best wishes for a healthy, productive, and pleasant school year.

### ***Acknowledgments***

I thank the following individuals for their various contributions throughout the many editions of this textbook.

Derek Abbot—University of Adelaide, Australia  
 Don Abernathy—DeVry Institute of Technology  
 Andrew H. Andersen, Jr. —Brookdale Community  
 College  
 James L. Antonakos—Broome Community College  
 Sohail Anwar—The Pennsylvania State University  
 Jeff Beasley—New Mexico State University  
 Tom Bellarmine—Florida A&M University  
 Bill Boettcher—Albuquerque Technical Vocational  
 Institute  
 Joe Booker—DeVry Institute of Technology  
 Mohamed Brihoum—DeVry Institute of Technology  
 O. J. Brittingham—DeVry Institute of Technology  
 Charles Bunting—Old Dominion University  
 Kern Butler—Town and Country Electric, Inc.  
 Mauro Caputi—Hofstra University  
 Richard Cliver—Rochester Institute of Technology  
 Joseph Coppola—State University of New York  
 Lester W. Cory—Southeastern Massachusetts  
 University  
 Thomas M. Crapo—Ricks College  
 Gerald L. Doult—DeVry Institute of Technology  
 John Dunbar—DeVry Institute of Technology  
 Derrek Butler Dunn—North Carolina A&T State  
 University  
 Richard Fleming—Midwestern State University  
 Marion R. Fox—Rose State College  
 Kenneth Frament—DeVry Institute of Technology  
 George Fredericks—Northeast State Technical  
 Community College  
 Alberto Gomez-Rivas—University of Houston

## VI Preface

Robert Herrick—Purdue University  
Robert J. Hofinger—Purdue University  
Tania Hrynewycz—DeVry Institute of Technology  
James Hurny—Rochester Institute of Technology  
Frank Jump—North Seattle Community College  
Rajiv Kapadia—Minnesota State University  
Robert Katz  
Mohammad I. Khan—Seneca College  
Ali Khidar—DeVry Institute of Technology  
Kathleen L. Kitto—Western Washington University  
Dave Krispinsky—Rochester Institute of Technology  
Noel Looser—Omega Corporation  
M. David Luneau, Jr. —University of Arkansas  
Bill Mack—Harrisburg Area Community College  
Leei Mao—Greenville Technical College  
Robert Martin—Northern Virginia Community College  
Tim Christensen—Cadence Design Systems  
Tom Minnich—West Virginia University Institute  
of Technology  
Jalil Moghaddasi—Bronx Community College/CUNY  
Mike O'Rear—Chattahoochee Technical Institute  
Said Oucheriah—Northern Illinois University  
Carol Parcels—Hewlett-Packard Corp.  
Jay Porter—Texas A&M University  
Robert Powell—Oakland Community College  
Sandra L. Powell—Texas Instruments  
Carl E. Priode—Shawnee State University  
Vic Quiros—DeVry Institute of Technology  
Richard Skovhol—Embry-Riddle Aeronautical  
University  
Paul T. Svatik—Owens Community College  
Barbara Sweeney—AT&T archives  
Eric Tisdale—Ball State University  
Domingo L. Uy—Hampton University  
Thomas A. Varetoni—DeVry Institute

of Technology  
Misty Watson—DeVry Institute of Technology  
Lynda Wilkinson—North Seattle Community College  
Major Jim Wise—U. S. Naval Academy

# Contents in Brief

|    |   |    |   |
|----|---|----|---|
| 1  | Introduction                                | 15 | Series and Parallel ac Circuits             |
| 2  | Current and Voltage                         | 16 | Series-Parallel ac Networks                 |
| 3  | Resistance                                  | 17 | Methods of Analysis and Selected Topics(ac) |
| 4  | Ohm's Law, Power, and Energy                | 18 | Network Theorems(ac)                        |
| 5  | Series Circuits                             | 19 | Power(ac)                                   |
| 6  | Parallel Circuits                           | 20 | Resonance                                   |
| 7  | Series-Parallel Networks                    | 21 | Transformers                                |
| 8  | Methods of Analysis and Selected Topics(dc) | 22 | Polyphase Systems                           |
| 9  | Network Theorems                            | 23 | Decibels, Filters, and Bode Plots           |
| 10 | Capacitors                                  | 24 | Pulse Waveforms and the $R$ - $C$ Response  |
| 11 | Magnetic Circuits                           | 25 | Nonsinusoidal Circuits                      |
| 12 | Inductors                                   | 26 | System Analysis: An Introduction            |
| 13 | Sinusoidal Alternating Waveforms            |    | Appendixes                                  |
| 14 | The Basic Elements and Phasors              |    | Index                                       |

# Contents

## 1

---

### Introduction 1

- 1.1 The Electrical/Electronics Industry 1
- 1.2 A Brief History 3
- 1.3 Computer Analysis 10

## 2

---

### Current and Voltage 15

- 2.1 Current 15
- 2.2 Voltage 21
- 2.3 Fixed(dc)Supplies 24
- 2.4 Conductors and Insulators 36
- 2.5 Semiconductors 38
- 2.6 Ammeters and Voltmeters 38
- 2.7 Applications 41

## 3

---

### Resistance 51

- 3.1 Introduction 51
- 3.2 Resistance: Metric Units 52
- 3.3 Temperature Effects 56
- 3.4 Superconductors 61
- 3.5 Types of Resistors 65
- 3.6 Color Coding and Standard Resistor Values 72
- 3.7 Conductance 77
- 3.8 Ohmmeters 79

## **II Contents**

- 3.9** Thermistors 81
- 3.10** Photoconductive Cell 82
- 3.11** Varistors 83
- 3.12** Applications 83

## **4**

---

### **Ohm's Law, Power, and Energy 91**

- 4.1** Ohm's Law 91
- 4.2** Plotting Ohm's Law 95
- 4.3** Power 99
- 4.4** Wattmeters 103
- 4.5** Efficiency 104
- 4.6** Energy 107
- 4.7** Circuit Breakers, GFCIs, and Fuses 111
- 4.8** Applications 114
- 4.9** Computer Analysis 117

## **5**

---

### **Series Circuits 133**

- 5.1** Introduction 133
- 5.2** Series Circuits 135
- 5.3** Voltage Sources in Series 139
- 5.4** Kirchhoff's Voltage Law 140
- 5.5** Interchanging Series Elements 145
- 5.6** Voltage Divider Rule 146
- 5.7** Notation 150
- 5.8** Internal Resistance of Voltage Sources 157
- 5.9** Voltage Regulation 161
- 5.10** Measurement Techniques 162
- 5.11** Applications 164
- 5.12** Computer Analysis 166

## **6**

---

### **Parallel Circuits 180**



|      |                                  |     |
|------|----------------------------------|-----|
| 6.1  | Introduction                     | 180 |
| 6.2  | Parallel Elements                | 180 |
| 6.3  | Total Conductance and Resistance | 182 |
| 6.4  | Parallel Circuits                | 189 |
| 6.5  | Kirchhoff's Current Law          | 192 |
| 6.6  | Current Divider Rule             | 196 |
| 6.7  | Voltage Sources in Parallel      | 201 |
| 6.8  | Open and Short Circuits          | 202 |
| 6.9  | Voltmeters; Loading Effect       | 206 |
| 6.10 | Troubleshooting Techniques       | 210 |
| 6.11 | Applications                     | 211 |

## 7

---

### Series-Parallel Networks 233

|     |   |     |
|-----|---|-----|
| 7.1 | Series-Parallel Networks                    | 233 |
| 7.2 | Descriptive Examples                        | 238 |
| 7.3 | Ladder Networks                             | 245 |
| 7.4 | Voltage Divider Supply(Unloaded and Loaded) | 248 |
| 7.5 | Potentiometer Loading                       | 251 |
| 7.6 | Ammeter, Voltmeter, and Ohmmeter Design     | 254 |
| 7.7 | Grounding                                   | 259 |
| 7.8 | Computer Analysis                           | 264 |

## 8

---

### Methods of Analysis and Selected Topics(dc) 279

|     |                                  |     |
|-----|----------------------------------|-----|
| 8.1 | Introduction                     | 279 |
| 8.2 | Current Sources                  | 280 |
| 8.3 | Source Conversions               | 283 |
| 8.4 | Current Sources in Parallel      | 286 |
| 8.5 | Current Sources in Series        | 289 |
| 8.6 | Branch-Current Analysis          | 289 |
| 8.7 | Mesh Analysis(General Approach)  | 295 |
| 8.8 | Mesh Analysis(Format Approach)   | 304 |
| 8.9 | Nodal Analysis(General Approach) | 308 |