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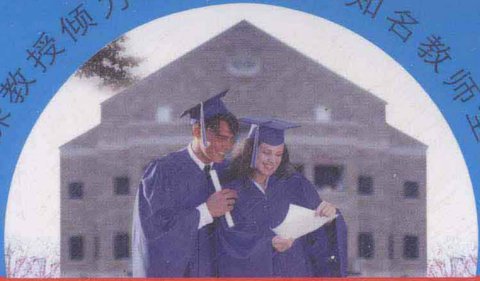


国外高校电子信息类优秀教材

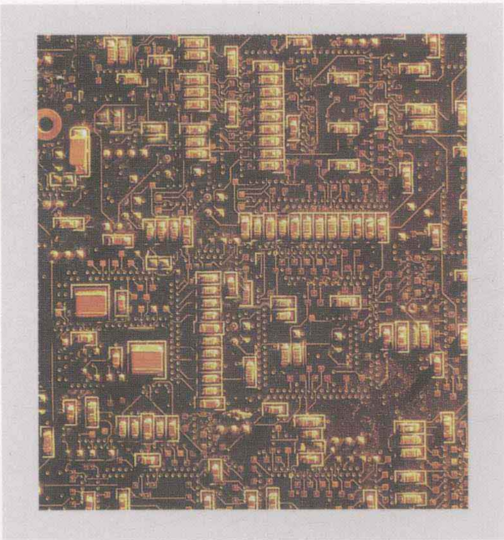
电路分析

（第二版）

Circuit Analysis: Theory and Practice

(Second Edition)

（英文影印版）



Allan H. Robbins　Wilhelm C. Miller　著

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国外高校电子信息类优秀教材(英文影印版)

电　路　分　析

（第二版）

Circuit Analysis: Theory and Practice

(Second Edition)

Allan H. Robbins　Wilhelm C. Miller 著

科 学 出 版 社

北　京

内 容 简 介

本书为国外高校电子信息类优秀教材(英文影印版)之一。

本书综合了电路分析的许多课题,包括DC和AC电路、分析方法、电容、电感、磁学、简单晶体管和计算机方法。全书贯穿了对OrCAD PSpice和Electronics Workbench两个流行的模拟软件的介绍。

本书可作为电子工程、计算机、通信、自动化等专业本科生教材,也可作为工程技术人员的参考书。

Circuit Analysis: Theory and Practice, 2nd ed.

By Allan H. Robbins, Wilhelm C. Miller

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国外高校电子信息类优秀教材(英文影印版)

丛 书 编 委 会

Preface

Welcome to the second edition of *Circuit Analysis: Theory and Practice.* If you are a student, we hope that this new edition will make your journey into learning circuit theory easier and more rewarding; if you are an instructor, we hope it will better assist you in your role as an educator. Although this book has a new look, it retains all the characteristics and usefulness of the previous version. In addition, it includes new and/or improved features such as an Online Companion™ web resource with RealAudio sound clips, Putting It Into Practice project-like problems that go beyond the usual end-of-chapter exercises, a CD-ROM-based e.resource™ with PowerPoint® Presentations, and more. Additionally, in response to instructor feedback, the end-of-chapter problem sets have been modified and expanded to provide a smoother transition from simple practice exercises to more challenging and in-depth problems.

The Book and Who it is For

Circuit Analysis: Theory and Practice was developed specifically for use in introductory circuit analysis courses. Written primarily as a textbook for electronics students in engineering technology programs, university engineering programs, industrial training programs and the like, it covers fundamentals of dc and ac circuits, methods of analysis, capacitance, inductance, magnetic circuits, basic transients, Fourier analysis, and other topics. When students successfully complete a course using this book, they will have a good working knowledge of basic circuit principles and a demonstrated ability to solve a variety of circuit-related problems.

Text Organization

The book contains 25 chapters and is divided into five main parts: Foundation DC Concepts, Basic DC Analysis, Capacitance and Inductance, Foundation AC Concepts, and Impedance Networks. Chapters 1 through 4 are introductory. They cover the foundation concepts of voltage, current, resistance, Ohm's Law, and power. Chapters 5 through 9 focus on dc analysis methods. Included are Kirchhoff's Laws, series and parallel circuits, mesh and nodal analysis, Y and Δ transformations, source transformations, Thévenin's and Norton's theorems, the maximum power transfer theorem, and so on. Chapters 10 through 14 cover basic concepts of capacitance, magnetism, and inductance, plus magnetic circuits and simple dc transients. Chapters 15 through 17 cover foundation concepts of ac, ac voltage generation, the basic ideas of frequency, period, phase, and so on. Phasors and the impedance concept are introduced and used to solve simple problems. Power in ac circuits is investigated and the concept of power factor and the power triangle are introduced. Chapters 18 through 25 then apply these ideas. Topics include ac versions of earlier dc techniques such as mesh and nodal analysis, Thévenin's theorem, and so on, as well as new ideas such as resonance, filters, Bode techniques, three-phase systems, transformers, and nonsinusoidal waveform analysis.

Several appendices round out the book: Appendix A provides a short tutorial on OrCAD PSpice; Appendix B reviews determinants and the solution of simultaneous equations; Appendix C provides additional material on the maximum power transfer theorem; and finally, Appendix D contains answers to selected odd-numbered end-of-chapter problems.

Features of the Book

New for the Second Edition

- Additional diagrams. The text now includes over 1200 full-color photos and diagrams (many of which incorporate 3-D effects) to illustrate and clarify ideas and to aid visual learners
- More problems, both easy and challenging. We now have over 1600 End-of-Chapter problems, Practice Problems and In-Process Learning Check problems
- Answers to Practice Problems have been moved from the appendix and placed with the practice problems to make it easier for students to verify their work
- OrCAD PSpice® and Electronics Workbench® computer simulation methods have been integrated throughout the text. Problems and examples make use of actual screen captures so that students see in the book exactly what they will see on their own computer screens
- A new feature, Putting It Into Practice, presents students with a group of challenging, project-like problems that require them to reason their way through realistic situations similar to those they experience on the job after graduation
- An Online Companion™ web site has been added. It contains RealAudio sound clips that present a more in-depth discussion of the most difficult topic for each chapter (keyed to the text by an icon)
- An extensive ancillary package has been created to include all solutions, PowerPoint slides, Image Library, Computerized Testbank/Gradebook, and Electronics Workbench® circuit files

Features from the First Edition

- Clearly written, easy-to-understand writing style that emphasizes principles and concepts
- Hundreds of worked-out and clearly illustrated examples to promote student understanding
- In-Process Learning Checks that help identify learning gaps before the student moves on to new material

- Chapter Previews provide a context and a brief overview for the upcoming chapter
- Competency-based objectives define the knowledge or skill that the student is expected to gain from each chapter
- Key terms at the beginning of each chapter identify new terms to be introduced
- Icons and graphics are used to direct the user's attention to focal points of the text
- Answers to odd-numbered problems are provided in an appendix

How to Use This Text

Since the most important attribute of a text is its value to the user, we have created a textbook that not only presents the technical material in an easy-to-read, easy-to-understand style, we have also provided in-text learning features that help the student in other ways. For example, each chapter includes a short vignette that provides insight into the development of the theory, important contributors met along the way, how the material relates to the electronic field in general, and so on. Some of these features are illustrated on the following pages.

Chapter Openers

Each chapter begins with an overview of the chapter, providing a perspective for the following chapter and an answer to "Why am I learning this?".

15 AC Fundamentals

OBJECTIVES

After studying this chapter, you will be able to

- explain how ac voltages and currents differ from dc,
- draw waveforms for ac voltage and currents and explain what they mean,
- explain the voltage polarity and current direction conventions used for ac,
- describe the basic ac generator and explain how ac voltage is generated,
- define and compute frequency, period, amplitude, and peak-to-peak values,
- compute instantaneous sinusoidal voltage or current at any instant in time,
- define the relationships between ω, T, and f for a sine wave,
- define and compute phase differences between waveforms,
- use phasors to represent sinusoidal voltages and currents,
- determine phase relationships between waveforms using phasors,
- define and compute average values for time-varying waveforms,
- define and compute effective values for time-varying waveforms,
- use Electronics Workbench and PSpice to study ac waveforms

KEY TERMS

ac
Alternating Voltage
Alternating Current
Amplitude
Angular Velocity
Average Value
Cycle
Effective Value
Frequency
Hertz
Instantaneous Value
Oscilloscope
Peak Value
Period
Phase Shifts
Phasor
RMS
Sine Wave

OUTLINE

CHAPTER PREVIEW

In Chapter 15, you learned how to analyze a few simple ac circuits in the time domain using voltages and currents expressed as functions of time. However, this is not a very practical approach. A more practical approach is to represent ac voltages and currents as phasors, circuit elements as impedances, and analyze circuits in the phasor domain using complex algebra. With this approach, ac circuit analysis is handled much like dc circuit analysis, and all basic relationships and theorems—Ohm's law, Kirchhoff's laws, mesh and nodal analysis, superposition and so on—apply. The major difference is that ac quantities are complex rather than real as with dc. While this complicates computational details, it does not alter basic circuit principles. This is the approach used in practice. The basic ideas are developed in this chapter.

Since phasor analysis and the impedance concept require a familiarity with complex numbers, we begin with a short review.

PUTTING IT IN PERSPECTIVE

Charles Proteus Steinmetz

CHARLES STEINMETZ WAS BORN IN Breslau, Germany in 1865 and emigrated to the United States in 1889. In 1892, he began working for the General Electric Company in Schenectady, New York, where he stayed until his death in 1923, and it was there that his work revolutionized ac circuit analysis. Prior to his time, this analysis had to be carried out using calculus, a difficult and time-consuming process. By 1893, however, Steinmetz had reduced the very complex alternating-current theory to, in his words, "a simple problem in algebra." The key concept in this simplification was the phasor—a representation based on complex numbers. By representing voltages and currents as phasors, Steinmetz was able to define a quantity called **impedance** and then use it to determine voltage and current magnitude and phase relationships in one algebraic operation.

Steinmetz wrote the seminal textbook on ac analysis based on his method, but at the time he introduced it he was practically the only person who understood it. Now, however, it is common knowledge and one of the basic tools of the electrical engineer and technologist. In this chapter, we learn the method and illustrate its application to the solution of basic ac circuit problems.

In addition to his work for GE, Charles Steinmetz was a professor of electrical engineering (1902–1913) and electrophysics (1913–1923) at Union University (now Union College) in Schenectady.

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Objectives and Key Terms

Chapter opening Objectives and Key Terms prepare students for recognition of key chapter topics and terms prior to chapter content.

Putting it In Perspective

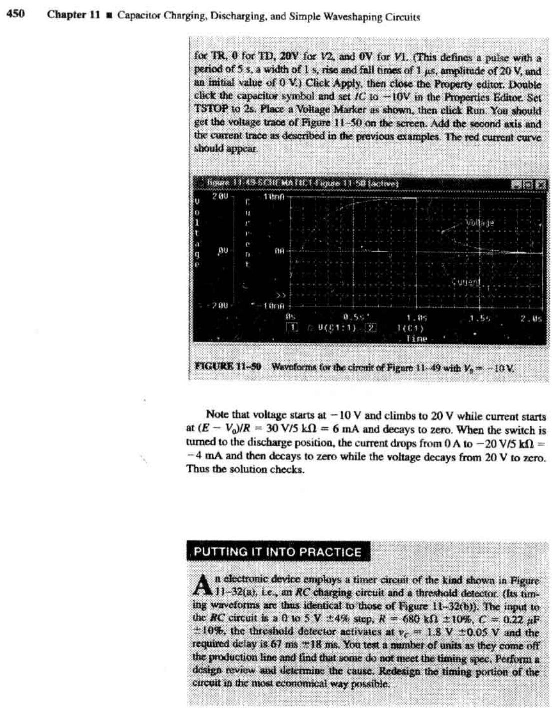
Short vignettes provide interesting background on the people and events leading to the major contributions in the electrical sciences. While entertaining, they provide insight and add a human element into the study of electric circuits.

Putting it Into Practice

This new feature allows students to develop problem-solving skills that are similar to those used by someone practicing in the electrical/electronics field. Putting it Into Practice offers students a challenging realistic problem to solve utilizing concepts learned in the preceding chapter.

Practice Problems

These problems are placed throughout the textbook (generally at the end of a section) to enable students to practice the skills that were learned in the section. The answers are found immediately after the practice problems so that students do not need to constantly flip through the textbook to see whether they are on the right track.


450 Chapter 11 ■ Capacitor Charging, Discharging, and Simple Waveshaping Circuits

for **TR**, **0** for **TD**, **20V** for *V2*, and **0V** for *V1*. (This defines a pulse with a period of 5 s, a width of 1 s, rise and fall times of 1 μs, amplitude of 20 V, and an initial value of 0 V.) Click **Apply**, then close the **Property** editor. Double click the capacitor symbol and set *IC* to −10V in the **Properties Editor**. Set **TSTOP** to 2s. Place a **Voltage Marker** as shown, then click **Run**. You should get the voltage trace of Figure 11–50 on the screen. Add the second axis and the current trace as described in the previous examples. The red current curve should appear.

FIGURE 11–50 Waveforms for the circuit of Figure 11–49 with $V_0 = -10$ V.

Note that voltage starts at −10 V and climbs to 20 V while current starts at $(E - V_0)/R$ = 30 V/5 kΩ = 6 mA and decays to zero. When the switch is turned to the discharge position, the current drops from 0 A to −20 V/5 kΩ = −4 mA and then decays to zero while the voltage decays from 20 V to zero. Thus the solution checks.

PUTTING IT INTO PRACTICE

An electronic device employs a timer circuit of the kind shown in Figure 11–32(a), i.e., an *RC* charging circuit and a threshold detector. (Its timing waveforms are thus identical to those of Figure 11–32(b)). The input to the *RC* circuit is a 0 to 5 V ±4% step, *R* = 680 kΩ ±10%, *C* = 0.22 μF ±10%, the threshold detector activates at v_C = 1.8 V ±0.05 V and the required delay is 67 ms ±18 ms. You test a number of units as they come off the production line and find that some do not meet the timing spec. Perform a design review and determine the cause. Redesign the timing portion of the circuit in the most economical way possible.

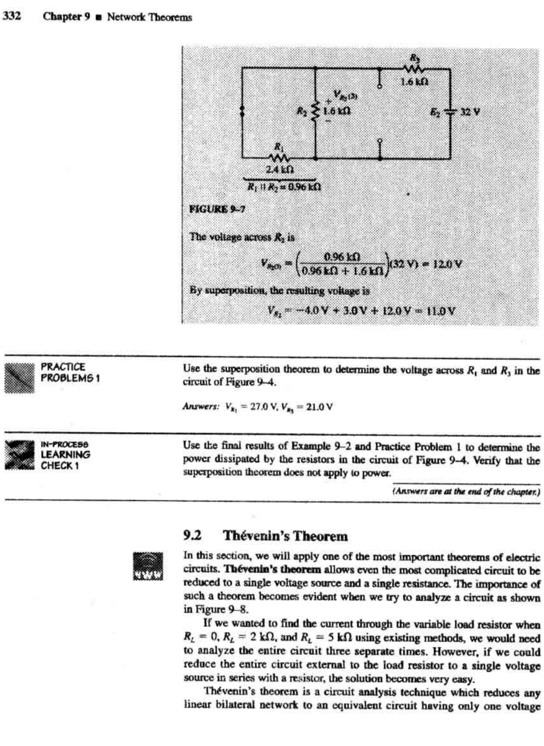

332 Chapter 9 ■ Network Theorems

FIGURE 9–7

The voltage across R_2 is

$$V_{R_2(3)} = \left(\frac{0.96\ \text{k}\Omega}{0.96\ \text{k}\Omega + 1.6\ \text{k}\Omega}\right)(32\ \text{V}) = 12.0\ \text{V}$$

By superposition, the resulting voltage is

$$V_{R_2} = -4.0\ \text{V} + 3.0\ \text{V} + 12.0\ \text{V} = 11.0\ \text{V}$$

PRACTICE PROBLEMS 1

Use the superposition theorem to determine the voltage across R_1 and R_3 in the circuit of Figure 9–4.

Answers: V_{R_1} = 27.0 V, V_{R_3} = 21.0 V

IN-PROCESS LEARNING CHECK 1

Use the final results of Example 9–2 and Practice Problem 1 to determine the power dissipated by the resistors in the circuit of Figure 9–4. Verify that the superposition theorem does not apply to power.

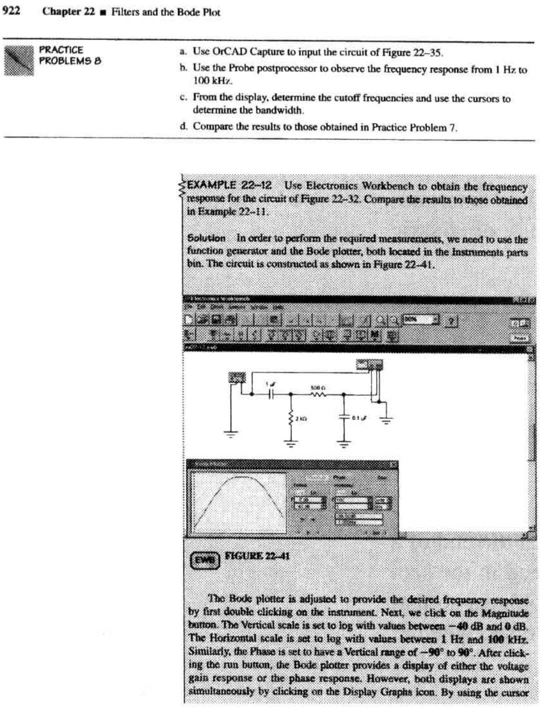
(Answers are at the end of the chapter.)

9.2 Thévenin's Theorem

In this section, we will apply one of the most important theorems of electric circuits. **Thévenin's theorem** allows even the most complicated circuit to be reduced to a single voltage source and a single resistance. The importance of such a theorem becomes evident when we try to analyze a circuit as shown in Figure 9–8.

If we wanted to find the current through the variable load resistor when $R_L = 0$, $R_L = 2$ kΩ, and $R_L = 5$ kΩ using existing methods, we would need to analyze the entire circuit three separate times. However, if we could reduce the entire circuit external to the load resistor to a single voltage source in series with a resistor, the solution becomes very easy.

Thévenin's theorem is a circuit analysis technique which reduces any linear bilateral network to an equivalent circuit having only one voltage



922 Chapter 22 ■ Filters and the Bode Plot

PRACTICE PROBLEMS 8

a. Use OrCAD Capture to input the circuit of Figure 22–35.
b. Use the Probe postprocessor to observe the frequency response from 1 Hz to 100 kHz.
c. From the display, determine the cutoff frequencies and use the cursors to determine the bandwidth.
d. Compare the results to those obtained in Practice Problem 7.

EXAMPLE 22–12 Use Electronics Workbench to obtain the frequency response for the circuit of Figure 22–32. Compare the results to those obtained in Example 22–11.

Solution In order to perform the required measurements, we need to use the function generator and the Bode plotter, both located in the Instruments parts bin. The circuit is constructed as shown in Figure 22–41.

EWB FIGURE 22–41

The Bode plotter is adjusted to provide the desired frequency response by first double clicking on the instrument. Next, we click on the Magnitude button. The Vertical scale is set to log with values between −40 dB and 0 dB. The Horizontal scale is set to log with values between 1 Hz and 100 kHz. Similarly, the Phase is set to have a Vertical range of −90° to 90°. After clicking the run button, the Bode plotter provides a display of either the voltage gain response or the phase response. However, both displays are shown simultaneously by clicking on the Display Graphs icon. By using the cursor

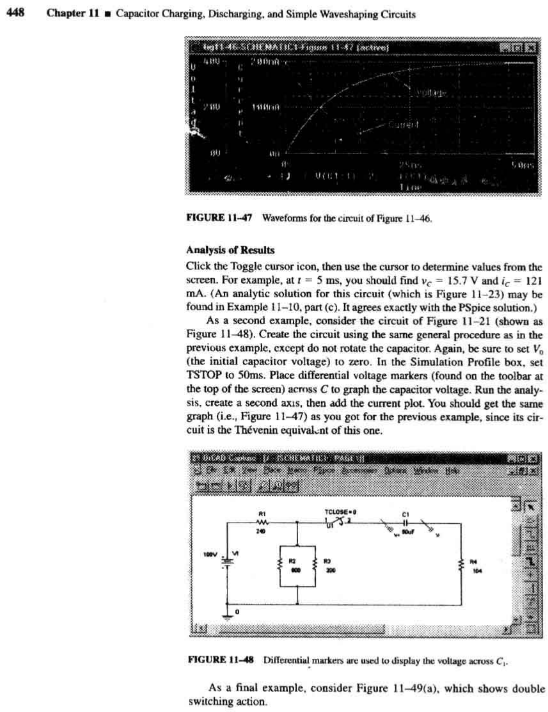


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FIGURE 11–47 Waveforms for the circuit of Figure 11–46.

Analysis of Results

Click the Toggle cursor icon, then use the cursor to determine values from the screen. For example, at t = 5 ms, you should find v_C = 15.7 V and i_C = 121 mA. (An analytic solution for this circuit (which is Figure 11–23) may be found in Example 11–10, part (c). It agrees exactly with the PSpice solution.)

As a second example, consider the circuit of Figure 11–21 (shown as Figure 11–48). Create the circuit using the same general procedure as in the previous example, except do not rotate the capacitor. Again, be sure to set V_0 (the initial capacitor voltage) to zero. In the Simulation Profile box, set TSTOP to 50ms. Place differential voltage markers (found on the toolbar at the top of the screen) across C to graph the capacitor voltage. Run the analysis, create a second axis, then add the current plot. You should get the same graph (i.e., Figure 11–47) as you got for the previous example, since its circuit is the Thévenin equivalent of this one.

FIGURE 11–48 Differential markers are used to display the voltage across C_1.

As a final example, consider Figure 11–49(a), which shows double switching action.

In-Process Learning Checks

In-Process Learning Checks provide a quick review of material just covered.

Examples

Numerous examples and solutions are included to help clarify topics and to guide the student to solve problems.

Online Companion™ Web Resources, RealAudio Clips

The authors have provided sound clips and have made them available to students via RealAudio on the text's Online Companion™ web site. These sound clips (one per chapter) present more in-depth discussions of the most difficult topic for each chapter, and will tie directly back to the text through a designated icon appearing in the text margins.

Computer Simulation

Two popular computer simulation programs, OrCAD PSpice and Electronics Workbench, are used in the book. Examples provide step-by-step instructions on how to construct circuits, connect meters, and test circuit operation. Results are then validated by comparison to theoretical results. Such simulation packages provide an additional way to enrich and add insight to the study of electrical circuits.

About OrCAD PSpice and MicroSim PSpice

For many years, users of this book have used PSpice from MicroSim Corporation. However, in early 1998, MicroSim was purchased by OrCAD and PSpice has now been integrated into the OrCAD suite of products. Because MicroSim PSpice is no longer available, all PSpice work in this book has been done using the demo version of OrCAD PSpice. However, to ease the migration for users who have not made the change, we have included PSpice Version 8 (i.e., MicroSim) versions of the PSpice material in this text on our web site at www.electronictech.com. For those users wanting a demo disk from OrCAD, please contact their web site at www.orcad.com.

Required Background

Students need a working knowledge of basic algebra and trigonometry and the ability to solve second-order linear equations such as those found in mesh analysis. They should be familiar with the SI metric system and the atomic nature of matter. In terms of higher math, calculus is introduced gradually in later chapters to aid in the development of ideas. (This is in keeping with ABET guidelines, which require the use of some calculus in accredited programs.) However, optional derivations and problems using calculus (which are provided for enrichment purposes) are marked by an ∫ icon and may be omitted in those programs that do not stress the use of calculus.

The Learning Package

The complete ancillary package was developed to achieve two goals:

1. To assist students in learning the essential information needed to prepare for the exciting field of electronics.
2. To assist instructors in planning and implementing their instructional programs for the most efficient use of time and other resources.

The *Circuit Analysis: Theory and Practice* package was created as an integrated whole. Supplements are linked to and integrated with the text to create a comprehensive supplement package that supports students and instructors. The package includes:

Laboratory Manual

Contains instructions for hands-on electronic lab work, plus additional computer simulation labs. It also includes a comprehensive guide to lab equipment and laboratory measurements.
ISBN: 0-7668-0627-8

Instructor's Resource Guide

Contains step-by-step solutions to all end-of-chapter (even and odd) problems, including waveforms, circuit diagrams and more. The Instructor's Resource Guide also includes the e.resource™ CD-ROM in the back of the book.
ISBN: 0-7668-0626-8

e.resource™

Available all on one CD-ROM are all the tools and instructional resources that will enrich your classroom. The elements of e.resource link directly to the text and tie together to provide a unified instructional system.

Features contained in the e.resource include:

PowerPoint® Presentation Slides: Provides customizable presentations for classroom use. Slides are prepared for every chapter of the book that helps you present key points and concepts. Graphics from the Image Library or your own images can be imported to create individualized classroom presentations.

Image Library: Includes 200 full-color images from the textbook, providing the instructor with another means of promoting student understanding. The Image Library allows the instructor to display or print images for a classroom presentation.

Computerized Testbank: Over 1000 questions for use in creating tests of varying levels so you can assess student comprehension.

Gradebook: Tracks student performance, prints student progress reports, organizes assignments, and more; simplifies administrative tasks.

Electronics Workbench Circuit Files: 100 circuits taken directly from the textbook. Instructors may copy and distribute these circuit files to students free of charge.

Electronics Technology Homepage: Includes Netscape Navigator so you can link directly to the Delmar Electronics Technology website and to the textbook's Online Companion for additional resources.

Online Companion™

One of the new features of this edition is a companion Internet web site, intended for use by both educators and students. It provides ongoing assistance in the form of additional problems, supplements, circuit schematics, updates on the status of EWB and OrCAD PSpice, and general information, plus a method whereby you can interact with the authors.

Features of the Online Companion include:

- RealAudio Sound Files
- Technology updates

- Internet activities
- Discussion forums
- Comprehensive listing of links to electronics industry and educational sites
- Ask the Authors: Frequently Asked Questions

Please visit our web site at www.electronictech.com for more details.

To the Student

Learning circuit theory should be challenging, interesting, and (hopefully) fun. However, it is also hard work, since the knowledge and skills that you seek can only be gained through practice. We offer a few guidelines.

1. As you go through the material, try to gain an appreciation of where circuit theory comes from—i.e., the basic experimental laws on which it is based. This will help you better understand the foundation ideas on which the theory is built.
2. Learn the terminology and definitions. Important new terms are introduced frequently. Learn what they mean and where they are used.
3. Study each new section carefully and be sure that you understand the basic ideas and how they are put together. Work your way through the examples with your calculator. Try the practice problems, then the end-of-chapter problems. Not every concept will be clear immediately and most likely many will require several readings before you gain an adequate understanding.
4. When you are ready, test your understanding using the In-Process Learning Checks (self-quizzes) located in each chapter.
5. When you have mastered the material, move on to the next block. For those concepts that you are having difficulty with, consult your instructor or some other authoritative source.

Calculators for Circuit Analysis

You will need a good scientific calculator. A good calculator will permit you to more easily master the numerical aspects of problem solving, thereby leaving you more time to concentrate on circuit theory itself. This is especially true for ac, where complex number work dominates. There are some inexpensive calculators on the market that handle complex-number arithmetic almost as easily as real-number arithmetic. Such calculators save an enormous amount of time. You should acquire such a calculator (after consulting with your instructor), and learn to use if proficiently.

Acknowledgements

Many people have contributed to the success of *Circuit Analysis: Theory and Practice.* We begin by expressing our thanks to our students for providing subtle (and sometimes not-so-subtle) feedback. Next, the reviewers and accuracy checkers: no textbook can be successful without the dedication and commitment of such people. We thank the following:

Reviewers

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Illinois Capacitor Inc.	Vansco Electronics

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Allan H. Robbins
Wilhelm C. Miller
August, 1999

About the Authors

Allan H. Robbins graduated from engineering with a Bachelor's degree and a Master's degree in Electrical Engineering. In graduate school, he specialized in circuit theory. Allan, who was formerly head of the Department of Electrical and Computer Technology at Red River College, has been an instructor for over 30 years. In addition to his academic career, he has been a consultant and a small business partner. He began writing as a contributing author for Osborne-McGraw-Hill in the computer field and is also joint author of one other textbook. He has served as Section Chairman for the IEEE and as a member of the board for the Electronics Industry Association of Manitoba.

Wilhelm (Will) C. Miller graduated from Electronic Engineering Technology and obtained his Bachelor of Science degree in Physics and Mathematics from the University of Winnipeg. He worked in the communications field for ten years, including a year's assignment with Saudi PTT in Jeddah, Saudi Arabia. Will has been an instructor in the Electronics and Computer Engineering Technologies for 18 years, having taught at Red River College and College of The Bahamas (Nassau, Bahamas). He is currently vice-president of CTTAM (the Certified Technicians and Technologists Association of Manitoba).

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