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NIGEL P. COOK

Introductory

DC/AC Electronics

Fourth Edition

Nigel P. Cook



PRENTICE HALL

Upper Saddle River, New Jersey

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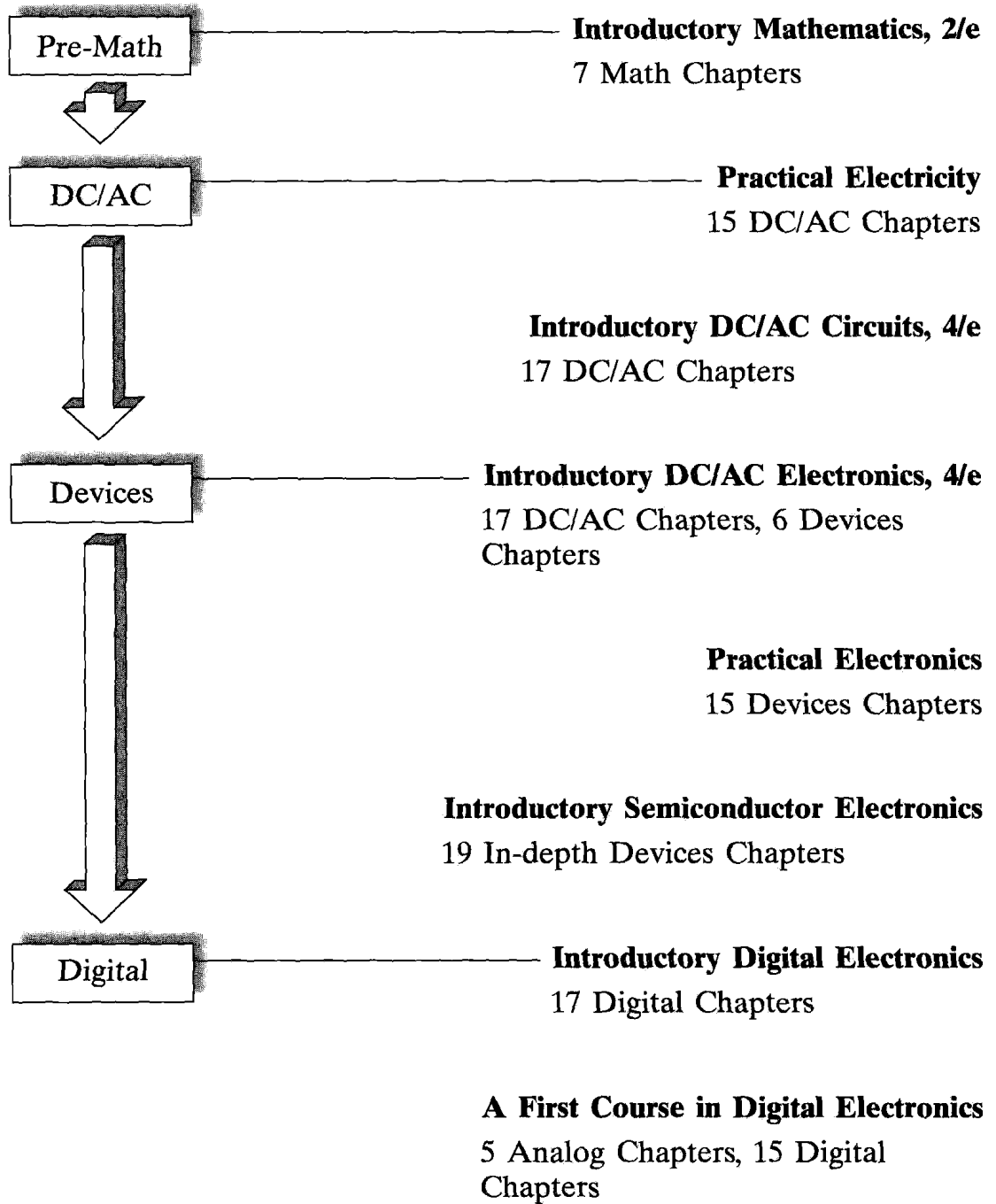
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To Dawn, Candy, and Jon

Titles by Nigel P. Cook



For more information on any of the other textbooks by Nigel Cook,
see his web page at: www.prenhall.com/cook or ask your local
Prentice Hall representative.

Preface

TO THE STUDENT

The early pioneers in electronics were intrigued by the mystery and wonder of a newly discovered science, whereas people today are attracted by its ability to lend its hand to any application and accomplish almost anything imaginable. If you analyze exactly how you feel at this stage, you will probably discover that you have mixed emotions about the journey ahead. On one hand, imagination, curiosity, and excitement are driving you on, while apprehension and reservations may be slowing you down. Your enthusiasm will overcome any indecision you have once you become actively involved in electronics and realize that it is as exciting as you ever expected it to be.

ORGANIZATION OF THE TEXTBOOK

This textbook has been divided into four basic parts. Chapters 1 through 5 introduce you to the world of electronics and the fundamentals of electricity. Chapters 6 through 9 cover direct current, or DC, circuits; Chapters 10 through 17 cover alternating current, or AC, circuits; and Chapters 18 through 23 cover semiconductor principles, devices, and circuits.

PART I The Fundamentals of Electricity

- Chapter 1 The World of Electronics
- Chapter 2 Voltage and Current
- Chapter 3 Resistance and Power
- Chapter 4 Resistors
- Chapter 5 Experimenting in the Lab

PART II Direct-Current Electronics

- Chapter 6 Direct Current (DC)
- Chapter 7 Series DC Circuits
- Chapter 8 Parallel DC Circuits
- Chapter 9 Series-Parallel DC Circuits

PART III Alternating-Current Electronics

- Chapter 10 Alternating Current (AC)

- Chapter 11 Experimenting in the Lab with AC
- Chapter 12 Capacitance and Capacitors
- Chapter 13 Capacitive Circuits, Testing, and Applications
- Chapter 14 Electromagnetism and Electromagnetic Induction
- Chapter 15 Inductance and Inductors
- Chapter 16 Transformers
- Chapter 17 Resistive, Inductive, and Capacitive (*RLC*) Circuits

PART IV Semiconductor Devices and Circuits

- Chapter 18 Semiconductor Principles
- Chapter 19 Junction Diodes
- Chapter 20 Diode Power Supply Circuits
- Chapter 21 Bipolar Junction Transistors (BJTs)
- Chapter 22 Field Effect Transistors (FETs)
- Chapter 23 Operational Amplifiers

The material covered in this book has been logically divided and sequenced to provide a gradual progression from the known to the unknown, and from the simple to the complex.

DEVELOPMENT, CLASS TESTING, AND REVIEWING

The first phase of development for this manuscript was conducted in the classroom with students and instructors as critics. Each topic was class-tested by videotaping each lesson, and the results were then evaluated and implemented. This invaluable feedback enabled me to fine-tune my presentation of topics and instill understanding and confidence in the students.

The second phase of development was to forward a copy of the revised manuscript to several instructors at schools throughout the country. Their technical and topical critiques helped to mold the text into a more accurate form.

The third and final phase was to class-test the final revised manuscript and then commission the last technical review in the final stages of production.



CIRCUIT SIMULATION USING THE ELECTRONICS WORKBENCH[®] CD-ROM

In the back of this book is a CD-ROM containing the circuit simulation software *Electronics Workbench[®] (EWB)*. Using the demo on this CD, you can simulate fifteen circuits taken directly from this text. The EWB icon shown here in the margin indicates which circuits in this text have been prebuilt and stored on the CD ready for simulation.

In addition to the EWB demo, the CD also contains an EWB tutorial, a complete locked version of EWB student version 5, and a circuit-set file containing over 150 circuits from Cook's dc/ac, devices, and digital texts.

ANCILLARIES ACCOMPANYING THIS TEXT

- A comprehensive **lab manual**, co-authored by Nigel Cook and Gary Lancaster, contains numerous experiments that are designed to translate all of the textbook's theory into practical experimentation.
- A **CD-ROM** is included in the back of this text containing a fully functional **Electronics Workbench® demo** and an **EWB tutorial**.
- An **Electronics Workbench® circuits file** is also included on the CD-ROM in the back of this book. This file contains many of this text's circuits pre-built and ready for simulation.
- An **MS PowerPoint® data disk** containing text figures can be used for overhead projection in the classroom.
- A **test item file manual** includes additional questions for tests and examinations. These questions are also available on a **test item file disk** that will operate with the Prentice Hall custom test generator.
- An **instructor's solutions manual** includes the full worked-out answers to all self-test review and end-of-chapter questions.
- A **companion www site** located at <http://www.prenhall.com/cook> that includes numerous interactive study questions designed to reinforce the concepts of the book.

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My appreciation and thanks are extended also to the following instructors who have reviewed and contributed greatly to the development of this textbook: Wade Jung, ITT Technical Institute; Joe Gryniuk, Jr., Lake Washington Technical College; Dr. Lee Rosenthal, Fairleigh Dickinson University; James W. Roberts, West Georgia Tech.; Dr. Robert Powell, Oakland Community College; Dr. Michael Chier, Milwaukee School of Engineering; Dr. Mauro Caputi, Hofstra University; Tony Hearn, Community College of Philadelphia; Doug Fuller, Humber College.

Nigel P. Cook

ILLUSTRATED TOUR OF TEXTBOOK FEATURES

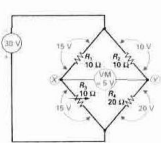


FIGURE 9-29 Unbalanced Wheatstone Bridge.

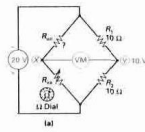
Determining Unknown Resistance

Figure 9-30 shows how a Wheatstone bridge circuit can be used to find the value of an unknown resistor (R_{un}). The variable-value resistor (R_v) is a calibrated resistor, which means that its resistance has been checked against a known, accurate resistance and its value can be adjusted and read from a calibrated dial.

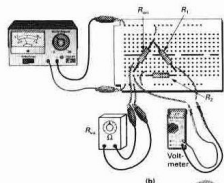
The procedure to follow to find the value of the unknown resistor is as follows:

1. Adjust the variable-value resistor until the voltmeter indicates that the Wheatstone bridge is balanced (voltmeter indicates 0 V).
2. Read the value of the variable-value resistor. As long as $R_1 = R_2$, the variable resistance value will be the same as the unknown resistance value.

$R_{\text{un}} = R_{\text{var}}$



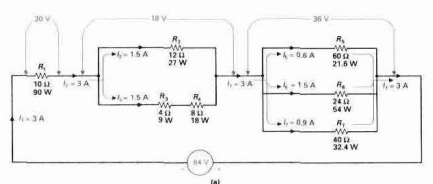
(a)



(b)

FIGURE 9-30 Using a Wheatstone Bridge to Determine an Unknown Resistance. (a) Schematic. (b) Pictorial.

SEC. 9.7/SERIES-PARALLEL CIRCUITS 333



(a)

Resistance $R = V/I$	Voltage $V = IR$	Current $I = V/R$	Power $P = VI$
$R_1 = 10\ \Omega$	$V_{R1} = 30\ \text{V}$	$I_1 = 3\ \text{A}$	$P_1 = 90\ \text{W}$
$R_2 = 12\ \Omega$	$V_{R2} = 18\ \text{V}$	$I_2 = 1.5\ \text{A}$	$P_2 = 27\ \text{W}$
$R_3 = 4\ \Omega$	$V_{R3} = 6\ \text{V}$	$I_3 = 1.5\ \text{A}$	$P_3 = 9\ \text{W}$
$R_4 = 8\ \Omega$	$V_{R4} = 12\ \text{V}$	$I_4 = 1.5\ \text{A}$	$P_4 = 18\ \text{W}$
$R_5 = 60\ \Omega$	$V_{R5} = 36\ \text{V}$	$I_5 = 0.6\ \text{A}$	$P_5 = 21.6\ \text{W}$
$R_6 = 24\ \Omega$	$V_{R6} = 36\ \text{V}$	$I_6 = 1.5\ \text{A}$	$P_6 = 54\ \text{W}$
$R_7 = 40\ \Omega$	$V_{R7} = 36\ \text{V}$	$I_7 = 0.9\ \text{A}$	$P_7 = 32.4\ \text{W}$
$R_T = 28\ \Omega$	$V_T = 84\ \text{V}$	$I_T = 3\ \text{A}$	$P_T = 252\ \text{W}$

(b)

FIGURE 9-18 Series-Parallel Circuit Example with All Information Inserted. (a) Schematic. (b) Circuit Analysis Table.

Solving for Resistance, Voltage, Current, and Power in a Series-Parallel Circuit

STEP 1 Determine the circuit's total resistance.

Step A Solve for series-connected resistors in all parallel combinations.

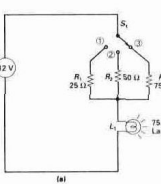
Step B Solve for all parallel combinations.

Step C Solve for remaining series resistances.

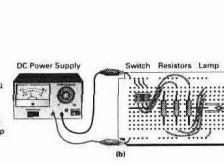
324 CHAPTER 9/SERIES-PARALLEL DC CIRCUITS

The CD-ROM in the back of this text contains the circuit simulation software *Electronics Workbench*®. Circuit simulation icons have been included in the margin to indicate which of the text's circuits have been prebuilt and included on the CD for simulation.

Circuit analysis tables train the student to collect circuit facts in an easy-to-read table that enables the student to clearly see total and individual current, voltage, resistance, and power values and relationships.



(a)



(b)

Resistance $R = V/I$	Current $I = V/R$	Voltage $V = IR$	Power $P = VI$
$S_1 = (1)$ $R_T = 25\ \Omega$	$I_T = 120\ \text{mA}$		
$S_1 = (2)$ $R_T = 50\ \Omega$	$I_T = 96\ \text{mA}$		
$S_1 = (3)$ $R_T = 75\ \Omega$	$I_T = 80\ \text{mA}$		
$R_T = 75\ \Omega$			

(c)

FIGURE 7-8 Three-Position Switch Controlling Lamp Brightness. (a) Schematic. (b) Protoboard Circuit. (c) Circuit Analysis Table.

Position 2: $R_T = R_1 + R_{\text{lamp}} = 50\ \Omega + 75\ \Omega = 125\ \Omega$
 $I_T = \frac{V_T}{R_T} = \frac{12\ \text{V}}{125\ \Omega} = 96\ \text{mA}$

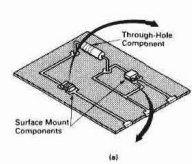
Position 3: $R_T = R_1 + R_{\text{lamp}} = 75\ \Omega + 75\ \Omega = 150\ \Omega$
 $I_T = \frac{V_T}{R_T} = \frac{12\ \text{V}}{150\ \Omega} = 80\ \text{mA}$

The details of this circuit are summarized in the analysis table shown in Figure 7-8(c).

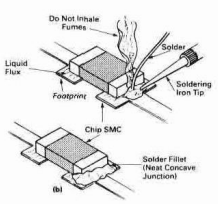
SELF/TEST REVIEW QUESTIONS FOR SECTION 7-3

1. State the total resistance formula for a series circuit.
2. Calculate R_T if $R_1 = 2\ \text{k}\Omega$, $R_2 = 3\ \text{k}\Omega$, and $R_3 = 4700\ \Omega$.

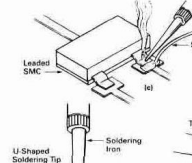
238 CHAPTER 7/SERIES DC CIRCUITS



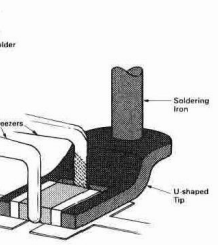
(a)



(b)



(c)



(d)

FIGURE 5-38 Soldering Surface Mount Components (SMCs).

SEC. 5.4/SOLDERING TOOLS AND TECHNIQUES 187

Protoboard pictorials help the beginning student make the transition from circuit schematic on paper to constructed circuit on a protoboard.

New technology topics have been added, such as how to solder and desolder surface mount components (SMCs).

Inductance and Inductors

Vignette: What's Cooking?

Introduction

15-1 Self-Induction (Objectives 1)

15-2 The Inductor

15-3 Factors Determining Inductance (Objectives 2 and 3)

15-3-1 Number of Turns (N)

15-3-2 Area of Coil (A)

15-3-3 Length of Coil (l)

15-3-4 Core Material (μ)

15-3-5 Formula for Inductance

15-4 Inductors in Combination (Objectives 4)

15-4-1 Inductors in Series

15-4-2 Inductors in Parallel

15-5 Types of Inductors (Objectives 5)

15-5-1 Fixed-Value Inductors

15-5-2 Variable-Value Inductors

15-5-3 Air Core

15-5-4 Iron Core

15-5-5 Ferrite Core

15-6 Inductive Time Constant (Objectives 6)

15-6-1 DC Current Rise

15-6-2 DC Current Fall

15-6-3 AC Rise and Fall

15-7 Inductive Reactance (Objectives 7)

15-8 Series RL Circuit (Objectives 8)

15-8-1 Voltage

15-8-2 Impedance (Z)

15-8-3 Phase Shift

15-8-4 Power

15-9 Parallel RL Circuit (Objectives 9)

15-9-1 Current

15-9-2 Phase Angle

15-9-3 Impedance

15-9-4 Power

15-10 Testing Inductors (Objectives 10)

15-10-1 Open

15-10-2 Complete or Section Short

15-11 Applications of Inductors (Objectives 11)

15-11-1 RL Filters

15-11-2 RL Integrator

15-11-3 RL Differentiator

Each chapter opening lists performance-based objectives, with each objective directly correlated to a chapter section on the following page.

THE TECHNICIAN

The technician is an expert in the use of test equipment and troubleshooting techniques, and uses both to aid in the design, manufacture and service of a product. The technician is also able to repair or replace the isolated faulty component.



THE ENGINEER

The engineer creates the concepts and designs of all new electronic circuits and systems. The engineer will work closely with engineering technicians in the prototyping of the design and the repair of any development problems.



THE ASSEMBLER

The assembler is responsible for the manufacture of the final product. The training includes the correct component assembly and handling techniques.



FIGURE 1-13 The Technician, Engineer, and Assembler. (Photos courtesy of Hewlett-Packard Company.)

SUMMARY

1. Electronics is built on four basic roots or properties: current, voltage, resistance, and power.
2. Electronic components control the four basic roots or properties of electronics.
3. Groups of components are interconnected to perform certain functions, and these arrangements are known as circuits.
4. Just as components are the building blocks for circuits, circuits are in turn the building blocks for electronic equipment.
5. All electronic equipment can be categorized into one of six different branches or groups: communications, data processing, consumer, industrial, test and measurement, and biomedical.
6. The names for almost all the units of electricity and electronics are derived from early experimenters.
7. The four main quantities and units are:
 - a. Current, which is measured in amperes or amps
 - b. Voltage, which is measured in the unit of volts
 - c. Resistance, which is measured in ohms
 - d. Power, which is measured in watts

VIGNETTE

Problem-Solver

Charles Proteus Steinmetz (1865-1923) was an outstanding electrical genius who specialized in mathematics, electrical engineering, and chemistry. His three greatest electrical contributions were his investigation and discovery of the law of hysteresis, his investigations in lightning, which resulted in his theory on traveling waves, and his discovery that complex numbers could be used to solve ac circuit problems. Solving problems was in fact his specialty, and on one occasion he was commissioned to troubleshoot a failure on a large company system that no one else had been able to repair. After studying the symptoms and schematics for a short time, he chalked an X on one of the metal cabinets, saying that this was where they would find the problem, and left. He was right, and the problem was remedied to the relief of the company executives; however, they were not pleased when they received a bill for \$1000. When they demanded that Steinmetz itemize the charges, he replied—\$1 for making the mark and \$999 for knowing where to make the mark.

The strong message this vignette conveys is that you will get \$1 for physical labor and \$999 for mental labor, and this is a good example as to why you should continue in your pursuit of education.

INTRODUCTION

It was during a classroom lecture in 1820 that Danish physicist Hans Christian Oersted accidentally stumbled on an interesting reaction. As he laid a compass down on a bench he noticed that the compass needle pointed to an adjacent conductor that was carrying a current, instead of pointing to the earth's north pole. It was this discovery that first proved that magnetism and electricity were very closely related to one another. This phenomenon is now called *electromagnetism* since it is now known that any conductor carrying an electrical current will produce a magnetic field.

In 1831, the English physicist Michael Faraday explored further Oersted's discovery of electromagnetism and found that the process could be reversed. Faraday observed that if a conductor was passed through a magnetic field, a voltage would be induced in the conductor and cause a current to flow. This phenomenon is referred to as *electromagnetic induction*.

In this chapter we examine the terms and characteristics of electromagnetism (electricity to magnetism) and electromagnetic induction (magnetism to electricity).

MINI-MATH REVIEW

This mini-math review is designed to remind you of the mathematical details relating to transposition, which will be used in the following section.

Transposition

In the preceding section it was stated that

$$\text{current (I)} = \frac{\text{voltage (V)}}{\text{resistance (R)}} \text{ or } I = \frac{V}{R}$$

Like all formulas, this formula provides a relationship between quantities, or values. In this case we can determine the current flow in a circuit simply by dividing the voltage applied to the circuit by the circuit's resistance. If we ever need to calculate only current, this formula would be fine on its own. But what if we want to calculate voltage and we know current and resistance, or what if we want to calculate resistance and we know current and voltage? It is important to know how to rearrange or transpose a formula so that you can solve for any of the formula's quantities—this process is known as transposition.

As an example, calculate what voltage would cause 2 amperes of current to flow in a circuit having a resistance of 3 ohms.

To solve this problem, you first begin by placing the values in their appropriate position within the formula. In this example,

$$\text{current (I)} = \frac{\text{voltage (V)}}{\text{resistance (R)}}$$

Therefore,

$$2 \text{ amperes} = \frac{V}{3 \text{ ohms}}$$

or

$$2 = \frac{V}{3}$$

Before we proceed further in our attempt to determine the value of voltage (V), we must first discuss a few ground rules.

1. The equals sign divides the equation or formula into two halves, and in all cases the left half always equals the right half. Therefore,

$$\frac{2}{\text{left half}} = \frac{V}{3 \text{ right half}}$$

2. Although not always visible, you should always assume that there are lines under every number or letter in mathematics. For example,

$$\frac{2}{\text{underline}} = \frac{V}{\text{underline}}$$

Any number beneath the line needs to be divided into the number on the top of the line, as with any fraction.

Chapter 1 includes extensive information about the world of electronics and career opportunities for the electronics technician, providing interest in and motivation for the material which follows.

Mini-Math Reviews are included in appropriate places to review the necessary mathematics needed for the discussion at hand.

2-3-4 Fluid Analogy of Current and Voltage

An analogy is a comparison that describes the similarities between two otherwise different things. In this section, we will use a fluid analogy to reinforce your understanding of current and voltage.

In Figure 2-23(a), a system using a pump, pipes, and a waterwheel is being used to convert electrical energy into mechanical energy. When electrical energy is applied to the pump, it will operate and cause water to flow. The pump generates:

1. A high pressure at the outlet port, which pushes the water molecules out and into the system
2. A low pressure at the inlet port, which pulls the water molecules into the pump

The water current flow is in the direction indicated, and the high pressure or potential within the piping will be used to drive the waterwheel around, producing:

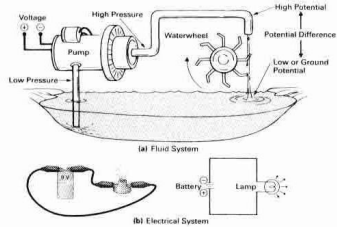


FIGURE 2-23 Comparison between a Fluid System (a) and an Electrical System (b).

SEC 2-3 / VOLTAGE 55

Concept analogies are used throughout the text to take the student from the known to the unknown.

8-5 POWER IN A PARALLEL CIRCUIT

As with series circuits, the total power in a parallel resistive circuit is equal to the sum of all the power losses for each of the resistors in parallel.

$$P_T = P_1 + P_2 + P_3 + P_4 + \dots$$

total power = addition of all the power losses

The formulas for calculating the amount of power dissipated are

$$P = I \times V$$

$$P = \frac{V^2}{R}$$

$$P = I^2 \times R$$

EXAMPLE:

Calculate the total amount of power dissipated in Figure 8-22.

Solution:

The total power dissipated in a parallel circuit is equal to the sum of all the power dissipated by all the resistors. With P_T , we only know voltage and resistance and therefore we can use the formula

$$P_1 = \frac{V_{R1}^2}{R_1} = \frac{20^2}{2 \text{ k}\Omega} = 0.2 \text{ W or } 200 \text{ mW}$$

With P_2 , we only know current and voltage, and therefore we can use the formula

$$P_2 = I_2 \times V_{R2} = 2 \text{ mA} \times 20 \text{ V} = 40 \text{ mW}$$

With P_3 , we know V , I , and R ; however, we will use the third power formula

$$P_3 = I_3^2 \times R_3 = 1 \text{ mA}^2 \times 20 \text{ k}\Omega = 20 \text{ mW}$$

Total power (P_T) equals the sum of all the power or wattage losses for each resistor

$$P_T = P_1 + P_2 + P_3 = 200 \text{ mW} + 40 \text{ mW} + 20 \text{ mW} = 260 \text{ mW}$$

Step	Keypad Entry	Display Response
1.	<input type="text" value="20"/>	20.
2.	<input type="text" value="2"/>	400.
3.	<input type="text" value="2"/>	2.00
4.	<input type="text" value="20"/>	2.00
5.	<input type="text" value="2"/>	0.2

Step	Keypad Entry	Display Response
1.	<input type="text" value="20"/>	1.6-4
2.	<input type="text" value="2"/>	1.6-4
3.	<input type="text" value="20"/>	20.
4.	<input type="text" value="2"/>	400.-4

Step	Keypad Entry	Display Response
1.	<input type="text" value="20"/>	1.6-4
2.	<input type="text" value="2"/>	1.6-4
3.	<input type="text" value="20"/>	20.
4.	<input type="text" value="2"/>	400.-4

SEC 8-5 / POWER IN A PARALLEL CIRCUIT 295

Calculator sequences are included in all examples that introduce new mathematical procedures, and a running glossary defines all new terms in the margin of the text.

EXAMPLE:

A common use of parallel circuits is in the residential electrical system. All of the household lights and appliances are wired in parallel, as seen in the typical room wiring circuit in Figure 8-15(a). If it is a cold winter morning, and lamps 1 and 2 are switched on, together with the space heater and hair dryer, what will the individual branch currents be, and what will be the total current drawn from the source?

Solution:

Figure 8-15(b) shows the schematic of the pictorial in Figure 8-15(a). Since all resistances are connected in parallel across a 120 V source, the voltage across all devices will be 120 V. Using Ohm's law we can calculate the four branch currents:

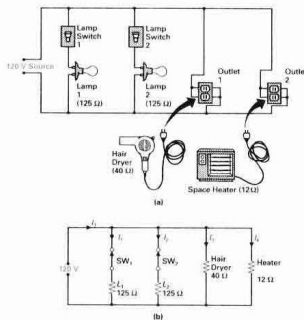


FIGURE 8-15 Parallel Home Electrical System.

SEC 8-3 / CURRENT IN A PARALLEL CIRCUIT 287

Actual circuit examples are included to help the student connect a topic to the real world.

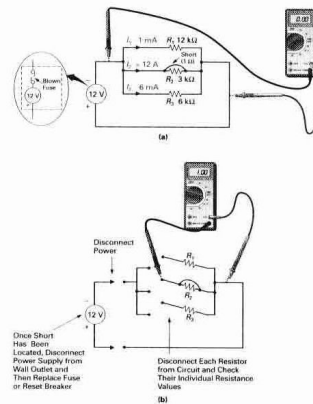


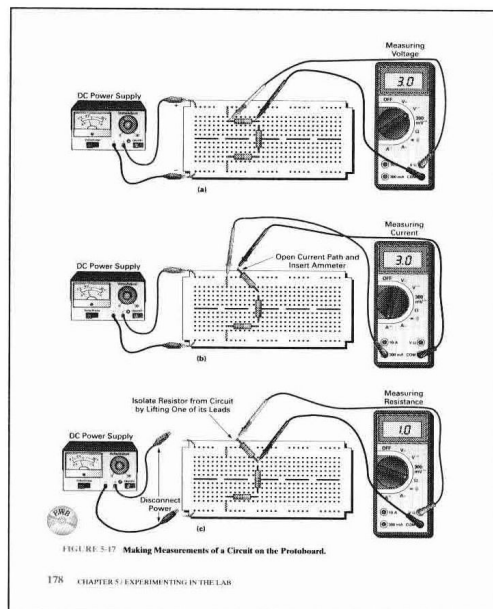
FIGURE 8-27 Troubleshooting a Short in a Parallel Circuit.

8-6-4 Summary of Parallel Circuit Troubleshooting

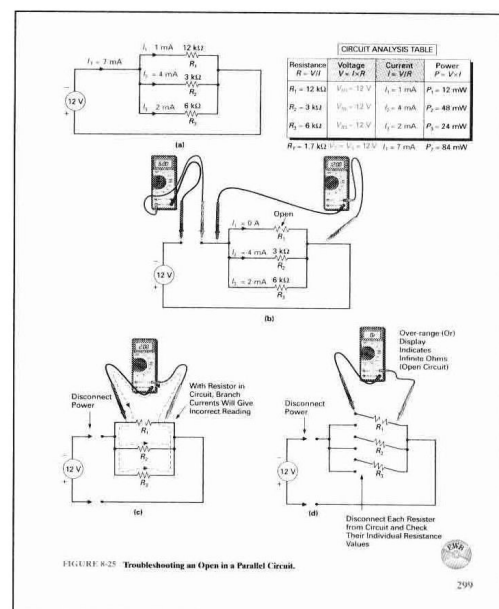
1. An open component will cause no current flow within that branch. The total current will decrease, and the voltage across the component will be the same as the source voltage.
2. A shorted component will cause maximum current through that branch. The total current will increase and the voltage source fuse will normally blow.

302 CHAPTER 8 / PARALLEL DC CIRCUITS

A strong testing, test equipment, and troubleshooting emphasis prepares the student for the working world.



Chapter 5 introduces the student to experimenting in the lab by covering safety, test equipment, protoboards, and soldering tools and techniques.



Unique diagrams and tables, coupled with the textbook's conversational writing style, make even traditionally difficult topics easily accessible.

QUICK REFERENCE SUMMARY SHEET

FIGURE 4-28 Resistor Color Code

General Purpose	Precision
First Digit	First Digit
Second Digit	Second Digit
Multiplicator	Multiplicator
Tolerance	Tolerance

Color	Digit Value	Multiplicator
Black	0	1 One
Brown	1	10 One Zero
Red	2	100 Two Zeros
Orange	3	1000 Three Zeros
Yellow	4	10000 Four Zeros
Green	5	100000 Five Zeros
Blue	6	1000000 Six Zeros
Violet	7	10000000 Seven Zeros
Grey	8	100000000 Eight Zeros
White	9	1000000000 Nine Zeros
Gold	—	10% or 0.1
Silver	—	5% or 0.05
None	—	20% or 0.2

e. The third band specifies the multiplier to be applied to the number, which ranges from $\times 1$ to $10,000,000$.

f. The fourth band describes the tolerance or deviation from the specified resistance, which is 25% or greater.

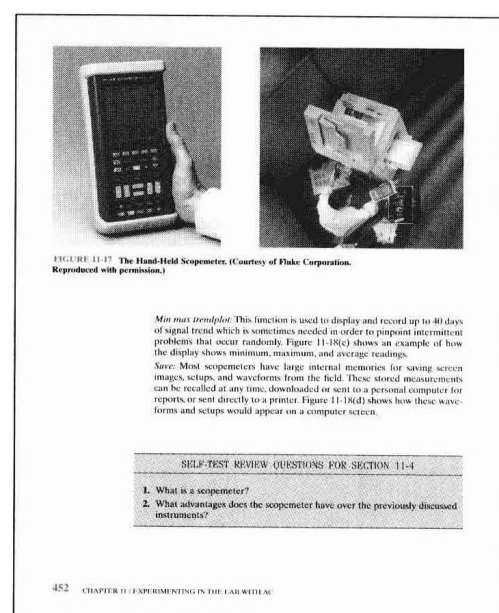
25. For the precision resistor code:

- The first band, like the general purpose resistor, is never black and is the first digit of the three-digit number.
- The second band provides the second digit.
- The third band indicates the third and last digit of the number.
- The fourth band specifies the multiplier to be applied to the number.
- The fifth and final band indicates the tolerance figure of the precision resistor, which is always less than 25%, which is why precision resistors are more expensive than general purpose resistors.

26. If a resistor color code is not found, some other form of marking will always be made on the resistor. The larger wirewound resistors and nearly all variable resistors normally have the resistance value, tolerance, and wattage printed on the resistor. SIP

SUMMARY 151

Quick Reference Summary Sheets within the end-of-chapter summary provide a visual reference to all key facts, symbols, circuits, and formulas.



Many new photos have been included to help student recognition.

34. An inductive or reactive analyzer can accurately test transformer windings, checking the inductance value of each coil.
35. It is virtually impossible to repair an open, partially shorted, or completely shorted transformer winding, and therefore defective transformers are always replaced with a transformer that has an identical rating.
36. Internal losses cause the power delivered from the secondary winding of a transformer in reality to be less than the power fed into the primary winding. These losses include ohmic resistance of the windings, hysteresis, local eddy currents in the core, and magnetic leakage.

REVIEW QUESTIONS

Multiple-Choice Questions

- Transformer action is based on:
 - Self inductance
 - Mutual inductance
 - Self capacitance
 - Mutual capacitance
- Are between the coils:
 - Self inductance
 - Mutual inductance
 - Self capacitance
 - Mutual capacitance
- An increase in transformer secondary current will cause a/an _____ in primary current.
 - Decrease
 - Increase
 - No change
 - Indeterminate
- If 50% of the magnetic lines of force produced by the primary were to cut the secondary coil, the coefficient of coupling would be:
 - 0.5
 - 0.25
 - 0.1
 - 0.05
- A step-up transformer will always have a turns ratio _____, while a step-down transformer has a turns ratio _____.
 - < 1 , > 1
 - > 1 , < 1
 - < 1 , < 1
 - > 1 , > 1
- With an 80 V ac secondary voltage center-tapped transformer, what would be the voltage at each output, and what would be the phase relationship between the two secondary voltages?
 - 20 V, in phase
 - 40 V, in phase
 - 20 V, 180° out of phase
 - 40 V, 180° out of phase
- One application of the autotransformer would be:
 - To obtain the final anode high voltage supply for the cathode ray tube in a television
 - To obtain two outputs, 180° out of phase with one another
 - To tap several different voltages from the secondary
 - To obtain the same secondary voltage for different voltages
- Transformers can only be used with alternating current because:
 - It produces an alternating magnetic field
 - It produces a fixed magnetic field
 - Its magnetic field is greater than that of dc
 - Its rms is 0.707 of the peak
- Eddy-current losses are reduced with laminated iron cores because:
 - The air gap is always kept to a minimum
 - The resistance of iron is always low
 - The laminations are all insulated from one another
 - Current cannot flow in iron
- Assuming 100% efficiency, the output power, P_o , is always equal to:
 - P_i
 - $V_o I_o$
 - Both (a) and (b)
 - 0.5 $\times P_i$

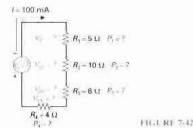


FIGURE 7-42

- Using a voltmeter, how would a short be recognized in a series circuit?
- If one of three series-connected bulbs is shorted, will the other two bulbs be on? Explain why.
- When one resistor in a series string is open, explain what would happen to the circuit.
 - Current
 - Resistance
 - Voltage across the open component
 - Voltage across the other components
- When one resistor in a series string is shorted, explain what would happen to the circuit.
 - Current
 - Resistance
 - Voltage across the shorted component
 - Voltage across the other components

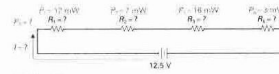


FIGURE 7-43

An extensive end-of-chapter test bank tests the student's understanding with multiple-choice questions, essay questions, practice problems, and troubleshooting questions.

- When troubleshooting series-parallel circuits, describe what effect (9-8-2):
 - A shorted series-connected resistor would have on total current and resistance, and how the shorted resistor could be isolated.
- Describe what effect a resistor's value variation would have and how it could be recognized (9-8-3).
- Give the divider formula, Ohm's law, and Kirchhoff's laws used to determine (9-6):
 - Branch currents
 - Voltage drops in a series-parallel circuit (List all six)

Practice Problems

- R_1 and R_2 are in series with one another and are both in parallel with R_3 . This parallel combination is in series with two series-connected resistors, R_4 and R_5 . $R_1 = 2.5 \text{ k}\Omega$, $R_2 = 10 \text{ k}\Omega$, $R_3 = 7.5 \text{ k}\Omega$, $R_4 = 2.5 \text{ k}\Omega$, $R_5 = 2.5 \text{ k}\Omega$, and $V_s = 100 \text{ V}$. For these values, calculate:
 - Total resistance
 - Total current
 - Voltage across series resistors and parallel combinations
 - Current through each resistor
 - Total and individual power figures
- Referring to the example in Question 36, calculate the voltage at every point of the circuit with respect to ground.
- A 10 V source is connected across a series-parallel circuit made up of R_1 in parallel with a branch made up of R_2 in series with a parallel combination of R_3 and R_4 . $R_1 = 10 \text{ k}\Omega$, $R_2 = 100 \text{ k}\Omega$, $R_3 = 200 \text{ k}\Omega$, and $R_4 = 300 \text{ k}\Omega$. For these values, apply the first-step procedure, and also determine the voltage at every point of the circuit with respect to ground.
- Calculate the output voltage (V_o) in Figure 9-71 if R_2 is equal to:
 - 25 Ω
 - 2.5 k Ω
 - 2.5 M Ω
- What load current will be supplied by the current source in Figure 9-72 if R_1 is equal to:
 - 25 Ω
 - 2.5 k Ω
 - 2.5 M Ω
- Use the superposition theorem to calculate total current:
 - Through R_1 in Figure 9-73(a)
 - Through R_2 in Figure 9-73(b)
- Convert the following voltage sources to equivalent current sources:
 - $V_s = 10 \text{ V}$, $R_s = 15 \text{ k}\Omega$
 - $V_s = 30 \text{ V}$, $R_s = 15 \text{ k}\Omega$
 - $V_s = 120 \text{ V}$, $R_s = 7 \text{ k}\Omega$

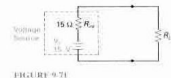


FIGURE 9-71

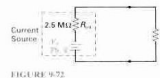


FIGURE 9-72

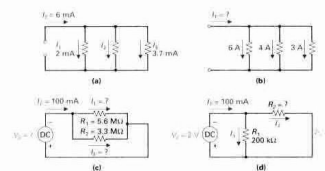


FIGURE 8-31 Calculate the Unknown.

- Calculate the following in Figure 8-31:
 - V_s
 - I_s
 - R_1
 - R_2
 - R_3
 - R_4
 - R_5
 - R_6
 - R_7
 - R_8
 - R_9
 - R_{10}
 - R_{11}
 - R_{12}
 - R_{13}
 - R_{14}
 - R_{15}
 - R_{16}
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 - R_{92}
 - R_{93}
 - R_{94}
 - R_{95}
 - R_{96}
 - R_{97}
 - R_{98}
 - R_{99}
 - R_{100}

Troubleshooting Questions

- An open component in a parallel circuit will cause _____ current flow within that branch, which will cause the total current to _____.
 - Maximum, increase
 - Zero, decrease
 - Zero, increase
 - Maximum, decrease
- A shorted component in a parallel circuit will cause _____ current through a branch, and consequently the total current will _____.
 - Maximum, increase
 - Maximum, decrease
 - Zero, decrease
 - Zero, increase
- If a 10 k Ω and two 20 k Ω resistors are connected in parallel across a 20 V supply, and the total current measured is 2 mA, determine whether a problem exists in the circuit and, if it does, isolate the problem.
- What situation would occur and how would we recognize the problem if one of the 20 k Ω resistors in Question 38 were to short?
 - With age, the resistance of a resistor will _____, resulting in a corresponding but opposite change in _____.
 - Increase, branch current
 - Decrease, source resistance
 - Change, branch current
 - Decrease, source resistance

Contents

PART I

The Fundamentals of Electricity 2

Chapter 1

The World of Electronics 2

Competitors Beware 4

Introduction 4

1-1 The Present 4

1-1-1 Communications Equipment 7

1-1-2 Data Processing Equipment 8

1-1-3 Consumer Equipment 10

1-1-4 Industrial Equipment 11

1-1-5 Test and Measurement Equipment 13

1-1-6 Biomedical Electronic Equipment 13

1-1-7 Electrical and Electronic Components, Circuits,
and Systems 13

1-2 The Past 15

1-3 The Future 20

1-4 Careers in Electronics 20

Chapter 2

Voltage and Current 26

Creating a Lot of Static 28

Introduction 28

2-1 The Structure of Matter 28

2-1-1 The Atom 29

2-1-2 Laws of Attraction and Repulsion 34

2-1-3 The Molecule 35

2-2 Current 39

2-2-1 Coulombs per Second 41

2-2-2 The Ampere 42

2-2-3 Units of Current 43

2-2-4 The Speed of Current Flow 45

2-2-5 Conventional versus Electron Flow 46

2-2-6 How Is Current Measured? 47

2-3 Voltage 47

2-3-1 Symbols 50

2-3-2 Units of Voltage 52

2-3-3 How Is Voltage Measured? 52

2-3-4 Fluid Analogy of Current and Voltage 55

2-3-5 Current Is Directly Proportional to Voltage 56

2-4 Conductors 57

2-4-1 Conductance 58

2-5 Insulators 61

2-6 The Open, Closed, and Short Circuit 62

2-6-1 Open Circuit (Open Switch) 62

2-6-2 Open Circuit (Open Component) 62

2-6-3 Closed Circuit (Closed Switch) 63

2-6-4 Short Circuit (Shorted Component) 63

Chapter 3

Resistance and Power 74

Genius of Chippewa Falls 76

Introduction 76

3-1 What Is Resistance? 77

3-2 The Ohm 79

3-2-1 Ohm's Law 79

3-2-2 The Ohm's Law Triangle 83

3-2-3 Current Is Proportional to Voltage 85

3-2-4 Current Is Inversely Proportional to
Resistance 87

3-3 Conductors and Their Resistance 89

3-3-1 Conducting Material 90

3-3-2 Conductor's Cross-Sectional Area 90

3-3-3 Conductor Length 92

3-3-4 Physical Resistance Formula 92

3-3-5 Temperature Effects on Conductors 93

3-3-6 Maximum Conductor Current 94

3-3-7 Superconductivity 95

3-3-8 Conductor and Connector Types 96

3-4 Energy, Work, and Power 97

3-4-1 Power 100

3-4-2 Calculating Energy 100

3-4-3 Calculating Power 101

3-4-4 Measuring Power 104

3-4-5 The Kilowatt-Hour 106

Chapter 4

Resistors 118

At the Core of Apple 120

Introduction 120

4-1 Resistor Types 121

4-1-1 Fixed-Value Resistors 122

4-1-2 Variable-Value Resistors 127

4-2 How Is Resistance Measured? 137

4-3 Resistor Coding 138

4-3-1 General-Purpose and Precision Color Code 139

4-3-2 Zero-Ohms Resistor 141

4-3-3 Other Resistor Identification Methods 142

4-4 Power Dissipation Due to Resistance 143

4-5 Filament Resistor 145

4-6 Testing Resistors 147

6-1 Source and Load 198

6-2 Direct-Current Sources 201

6-2-1 Mechanically Generated DC:
Mechanical→Electrical 201

6-2-2 Thermally Generated DC:
Heat→Electrical 203

6-2-3 Optically Generated DC:
Light→Electrical 203

6-2-4 Magnetically Generated DC:
Magnetic→Electrical 205

6-2-5 Chemically Generated DC:
Chemical→Electrical 205

6-2-6 Electrically Generated DC 212

6-3 Equipment Protection 214

6-3-1 Fuses 214

6-3-2 Circuit Breakers 217

6-4 Switches 220

Chapter 5

Experimenting in the Lab 156

The Great Experimenter 158

Introduction 159

5-1 Safety 159

5-1-1 Body Resistance 160

5-1-2 Precautions to Be Used When
Troubleshooting 161

5-1-3 First Aid, Treatment, Resuscitation 162

5-2 Test Equipment 164

5-2-1 The DC Power Supply 164

5-2-2 The Analog Multimeter (AMM) 165

5-2-3 The Digital Multimeter (DMM) 169

5-3 Protoboards 176

5-4 Soldering Tools and Techniques 179

5-4-1 Soldering Tools 179

5-4-2 Wetting 180

5-4-3 Solder and Flux 180

5-4-4 Soldering Irons 182

5-4-5 Soldering Techniques 184

5-4-6 Desoldering 185

5-4-7 How to Solder and Desolder Surface Mount
Components (SMCs) 186

5-4-8 Safety 189

Chapter 7

Series DC Circuits 228

Hitler's Computer Mistake 230

Introduction 230

7-1 Components in Series 230

7-2 Current in a Series Circuit 233

7-3 Resistance in a Series Circuit 235

7-4 Voltage in a Series Circuit 239

7-4-1 A Voltage Source's Internal
Resistance 244

7-4-2 Fixed Voltage Divider 246

7-4-3 Variable Voltage Divider 253

7-5 Power in a Series Circuit 257

7-5-1 Maximum Power Transfer 261

7-6 Troubleshooting a Series Circuit 263

7-6-1 Open Component in a Series Circuit 263

7-6-2 Component Value Variation in a Series
Circuit 265

7-6-3 Shorted Component in a Series
Circuit 266

PART II

Direct-Current Electronics 196

Chapter 6

Direct Current (DC) 196

The First Computer Bug 198

Introduction 198

Chapter 8

Parallel DC Circuits 274

Bringing Home the Bacon 276

Introduction 276

8-1 Components in Parallel 276

8-2 Voltage in a Parallel Circuit 277

8-3 Current in a Parallel Circuit 281

8-4 Resistance in a Parallel Circuit 288

8-4-1 Two Resistors in Parallel 291

8-4-2 Equal-Value Resistors in Parallel 291

8-5 Power in a Parallel Circuit 295

8-6 Troubleshooting a Parallel Circuit	298
8-6-1 Open Component in a Parallel Circuit	298
8-6-2 Shorted Component in a Parallel Circuit	301
8-6-3 Component Value Variation in a Parallel Circuit	301
8-6-4 Summary of Parallel Circuit Troubleshooting	302

Chapter 9

Series-Parallel DC Circuits 310

The Christie Bridge Circuit 312

Introduction 313

9-1 Series- and Parallel-Connected Components	313
9-2 Total Resistance in a Series-Parallel Circuit	316
9-3 Voltage Division in a Series-Parallel Circuit	319
9-4 Branch Currents in a Series-Parallel Circuit	321
9-5 Power in a Series-Parallel Circuit	322
9-6 Five-Step Method for Series-Parallel Circuit Analysis	323
9-7 Series-Parallel Circuits	328
9-7-1 Loading of Voltage-Divider Circuits	328
9-7-2 The Wheatstone Bridge	330
9-7-3 The $R-2R$ Ladder Circuit	335
9-8 Troubleshooting Series-Parallel Circuits	339
9-8-1 Open Component	340
9-8-2 Shorted Component	342
9-8-3 Resistor Value Variation	344
9-9 Theorems for DC Circuits	348
9-9-1 Voltage and Current Sources	348
9-9-2 Superposition Theorem	352
9-9-3 Thévenin's Theorem	356
9-9-4 Norton's Theorem	360

PART III

Alternating-Current Electronics 372

Chapter 10

Alternating Current (AC) 372

The Laser 374

Introduction 374

10-1 The Difference between DC and AC	375
---------------------------------------	-----

10-2 Why Alternating Current?	378
10-2-1 Power Transfer	378
10-2-2 Information Transfer	383
<i>Mini-Math Review—Trigonometry</i>	387
10-3 AC Wave Shapes	397
10-3-1 The Sine Wave	397
10-3-2 The Square Wave	410
10-3-3 The Rectangular or Pulse Wave	417
10-3-4 The Triangular Wave	420
10-3-5 The Sawtooth Wave	422
10-3-6 Other Waveforms	423
10-4 Electricity and Electronics	425

Chapter 11

Experimenting in the Lab with AC 434

Logging On 436

Introduction 436

11-1 The AC Meter	437
11-1-1 Current Clamps	438
11-1-2 Radio-Frequency Probe	440
11-1-3 High-Voltage Probe	440
11-2 The Oscilloscope	442
11-2-1 Controls	443
11-2-2 Measurements	446
11-3 The Function Generator and Frequency Counter	450
11-4 Hand-Held Scopemeters	451

Chapter 12

Capacitance and Capacitors 458

Sounds Like Electronics 460

Introduction 460

12-1 Capacitor Construction	461
12-2 Charging and Discharging a Capacitor	461
12-2-1 Charging a Capacitor	462
12-2-2 Discharging a Capacitor	464
12-3 Electrostatics	464
12-4 The Unit of Capacitance	467
12-5 Factors Determining Capacitance	470
12-5-1 Plate Area (A)	470
12-5-2 Distance between the Plates (d)	471
12-5-3 Dielectric Constant	472
12-5-4 The Capacitance Formula	473
12-6 Dielectric Breakdown and Leakage	474

12-7 Capacitors in Combination	476
12-7-1 Capacitors in Parallel	476
12-7-2 Capacitors in Series	477
12-8 Types of Capacitors	481
12-8-1 Fixed-Value Capacitors	482
12-8-2 Variable-Value Capacitors	488
12-8-3 The One-Farad Capacitor	491
12-9 Coding of Capacitance Values	493
12-9-1 Alphanumeric Labels	493
12-9-2 Color Coding	495
12-10 Capacitive Time Constant	496
12-10-1 DC Charging	496
12-10-2 DC Discharging	500
12-11 AC Charge and Discharge	502
12-12 Phase Relationship between Capacitor Current and Voltage	504

Chapter 13

Capacitive Circuits, Testing, and Applications 514

Let's Toss for It! 516

Introduction 516

13-1 Capacitive Reactance	517
13-2 Series RC Circuit	519
13-2-1 Vector Diagram	521
13-2-2 Voltage	522
13-2-3 Impedance	524
13-2-4 Phase Angle or Shift (θ)	526
13-2-5 Power	528
13-3 Parallel RC Circuit	534
13-3-1 Voltage	534
13-3-2 Current	534
13-3-3 Phase Angle	535
13-3-4 Impedance	536
13-3-5 Power	536
13-4 Testing Capacitors	538
13-4-1 The Ohmmeter	538
13-4-2 The Capacitance Meter or Analyzer	540
13-5 Applications of Capacitors	541
13-5-1 Combining AC and DC	542
13-5-2 The Capacitive Voltage Divider	542
13-5-3 RC Filters	542
13-5-4 The RC Integrator	546
13-5-5 The RC Differentiator	549

Chapter 14

Electromagnetism and Electromagnetic Induction 560

Problem-Solver 562

Introduction 562

14-1 Electromagnetism	563
14-1-1 Atomic Theory of Electromagnetism	563
14-1-2 DC, AC, and the Electromagnet	563
14-1-3 Magnetic Terms	567
14-1-4 Flux Density (B) versus Magnetizing Force (H)	572
14-1-5 Applications of Electromagnetism	575
14-2 Electromagnetic Induction	583
14-2-1 Faraday's Law	584
14-2-2 Lenz's Law	585
14-2-3 The Weber	586
14-2-4 Applications of Electromagnetic Induction	586

Chapter 15

Inductance and Inductors 600

What's Cooking! 602

Introduction 603

15-1 Self-Induction	603
15-2 The Inductor	606
15-3 Factors Determining Inductance	607
15-3-1 Number of Turns (N)	607
15-3-2 Area of Coil (A)	608
15-3-3 Length of Coil (l)	608
15-3-4 Core Material (μ)	609
15-3-5 Formula for Inductance	610
15-4 Inductors in Combination	611
15-4-1 Inductors in Series	611
15-4-2 Inductors in Parallel	612
15-5 Types of Inductors	613
15-5-1 Fixed-Value Inductors	614
15-5-2 Variable-Value Inductors	616
15-6 Inductive Time Constant	617
15-6-1 DC Current Rise	618
15-6-2 DC Current Fall	619
15-6-3 AC Rise and Fall	621
15-7 Inductive Reactance	622
15-8 Series RL Circuit	624
15-8-1 Voltage	624
15-8-2 Impedance (Z)	626
15-8-3 Phase Shift	627
15-8-4 Power	629