



**INTRODUCTION TO**

**ELECTRICITY  
AND  
ELECTRONICS  
CONVENTIONAL  
CURRENT  
VERSION**

**THIRD  
EDITION**

**ALLEN MOTTERSHEAD**

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CURRENT VERSION**  

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**THIRD EDITION**

**ALLEN MOTTERSHEAD**

Department of Electronics Technology  
Cypress College, California



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# PREFACE

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Everyone knows that the world is becoming more complex. From the cars we drive to the calculators, computers, and entertainment equipment familiar to all, we take for granted the advances that electronics has brought. And yet, the fundamental principles that made many of these devices possible first had to be understood before such devices could be developed. This book provides the fundamentals of electricity, magnetism, and electronics to help you understand the world around you. Many everyday applications are described to show these fundamentals at work. Also, completion of the material in this book will allow you to study in detail the advanced theory and applications of electrical and electronic devices, circuits, and systems.

The book is written for the first-year course in an electricity/electronics program at a community college, vocational institute, technical college, and so on. It covers the traditional material of dc and ac circuits, including magnetism, that is required for both electronic and electrical majors. It assumes no previous knowledge of electricity or electronics. Only a basic understanding of algebra is required, and right-angle trigonometry is introduced only when it is necessary to understand alternating current.

There are three parts to the book. In Part One, after introducing calculators, electrical meters, and the basic electrical quantities, series and parallel circuits are covered followed by series-parallel circuits and their applications in loaded voltage dividers. A comprehensive chapter on voltage sources contains up-to-date information on the latest secondary batteries as well as fuel and solar cells. The important effect of internal resistance on maximum power transfer is also considered. A chapter on network analysis covers all the important methods such as branch currents, loop, superposition, Thévenin's, Norton's, nodal analysis, and delta-wye transformations. Magnetism is then covered so that its applications in dc ammeters, voltmeters, and other dc measuring instruments can be shown.

Part Two begins with the generation of alternating current (ac) and direct current (dc), and continues with a detailed coverage of alternating voltage and current. This includes a chapter on ac measuring instruments, concentrating on the oscilloscope and its use. The oscilloscope can then be referred to during the following chapters on inductance and capacitance where their effects in both dc and ac circuits are considered. A whole chapter on transformers is included. After treating various combinations of resistance, inductance, and capacitance in alternating circuits, a chapter on complex numbers follows. Power and resonance are then covered.

Part Three introduces the broad field of electronics. How a PN junction diode can cause rectification is explained, and its use to convert ac to dc in power supplies is followed by a discussion of filters. Finally, the bipolar junction transistor is introduced, and its use is demonstrated in amplifiers and oscillators.

The book has a number of features. First, theory and principles are made easier to understand by presenting applications whenever possible. For example, following a theoretical discussion of magnetism, we see how loudspeakers and dc motors operate, how solenoids and relays are used in a typical home heating/cooling system, and how the Hall effect is used in a clamp-on ammeter to measure both ac and dc.

In the chapter on electromagnetic induction we see the basic principles applied to a microphone, a magnetic tape recorder, a guitar pickup, practical alternators and dc generators, and a voltage regulator for an automotive battery-alternator system.

In the chapter on transformers, applications to power distribution and residential wiring systems are made, including the safety features of a ground connection and a ground fault circuit interrupter. Other applications include the conventional and electronic automotive ignition system, the role of an inductor in a fluorescent lamp circuit,

the use of capacitors in photoflash units, differentiating and delay circuits, and power factor correction applications. The chapter on resonance shows how the principles of resonance are applied to a superheterodyne AM receiver, and the chapter on diodes applies the principles of rectification to the three-phase output of an automobile's alternator.

Second, every opportunity is taken to show how measurements are properly made by the latest in instrumentation. Three chapters are devoted to dc and ac measuring instruments. The conventional meters to measure current, voltage, resistance, and power, both analog and digital, are examined, in addition to the following: Gaussmeter, potentiometer for voltmeter and ammeter calibration, Wheatstone bridge, frequency and period meter, instrument transformers, impedance bridge, capacitance and inductance meters, power factor meter, vector impedance and voltage meters, and curve tracers. The use of the oscilloscope is stressed in the measurement of time constants, inductance, capacitance, phase angle, quality factor, and so on.

Third, every chapter has a summary, self-examination, review questions, and problems. Answers to the self-examination questions and to the odd-numbered problems are at the back of the book. There is also a comprehensive glossary containing all the book's important terms, as well as the symbols and units of each electrical quantity. The appendixes contain 13 sections that cover tables of information on resistors, wire gauges, determinants, trigonometry ratios, derivations, and so on.

Fourth, the text is arranged so that material needed for a concurrent laboratory course is given early in the text. A laboratory manual is available that was written to accompany the text. The laboratory manual has one laboratory experiment with many sections, for almost every chapter in this book. It is designed to be used with most standard laboratory equipment and supplies.

Fifth, this book is available in both the *conventional-current version* and the *electron-flow version*. Although the SI system recommends the eventual adoption of conventional current, many will prefer to remain with the more familiar electron flow.

Finally, an instructor's manual is available with complete solutions to all problems, odd and even, as well as sample tests and figures suitable for making overhead transparencies.

Major additions or changes found in the third edition include:

- Chapter 1: A new section on wiring methods, including coverage of printed circuits and surface mount technology (SMT). Greater emphasis on digital meters.
- Chapter 4: A comprehensive section on superconductivity—its theory, applications, and problems.
- Chapter 5: A description of the Pacific Intertie HVDC transmission line as an application of positive and negative potentials.
- Chapter 7: A new section on the unloaded Wheatstone bridge as an example of voltage division.
- Chapter 8: New information on zinc-air and lithium cells. An application of solar cells and cellular communications to self-contained emergency call boxes.
- Chapter 10: Description and application of an alternate mesh current method.
- Chapter 14: Description of the guitar pickup as an application of electromagnetic induction.
- Chapter 25: Movement of the chapter on complex numbers (previously Chapter 27) to immediately follow the chapter on phasors in ac circuits.
- Chapter 26: Addition of an optional section showing how complex numbers may be used in "complex power" and power factor correction.
- Appendix: Addition of a comprehensive list of world primary power voltages and frequencies.
- Almost 200 brand-new problems have been added, most of them as "Review Problems." They are concentrated in groups covering chapters 1–4, 5–7, 8–10, 11–13, 14–16, 17–20, 21–23, and 24–27.

Questions and comments concerning the text are welcome and should be directed to me at Cypress College, Cypress, California, 90630.

Allen Mottershead

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A.M.

# TO THE INSTRUCTOR

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**T**his book may be used in a number of different ways.

- 1 For a conventional two-semester dc/ac course:  
Semester 1: Part I, DC Circuits: Chapters 1 to 13.  
Semester 2: Part II, AC Circuits: Chapters 14 to 27.
- 2 An alternate two-semester dc/ac course may use the following sequence:  
Semester 1: DC Circuits: Chapters 1–10, 21, 22, 11, 17, 19, 12, and 13.  
Semester 2: AC Circuits: Chapters 14, 15, 18, 16, 20, and 23–27.
- 3 For a one-semester combination dc/ac course (no analysis) that may include nonelectrical/electronics majors, the following chapters and sections are recommended:

Week	DC Circuits
1	Chapter 1—read lightly Chapter 2
2	Chapter 3
3	Section 4-1 and Chapter 5
4	Chapter 6 Section 7-1
5	Chapter 8—read lightly Chapter 9
6	Chapter 11—Omit Sections 11-11, 11-14, and 11-15
7	Chapter 12—Omit Section 12-4 Chapter 13—Omit Sections 13-1, 13-4, and 13-6

Week	AC Circuits
8	Chapter 14—All plus Appendix F
9	Chapter 15 Sections 16-1 and 16-6
10	Chapter 17—Omit Sections 17-2, 17-5.3, and 17-5.4

- |    |  |
|----|--|
|    | Chapter 18—Omit Sections 18-1.4 and 18-6   |
| 11 | Chapter 19—Omit Sections 19-4, 19-6.1, 19-6.2, and 19-10<br>Chapter 20—Omit Sections 20-4, and 20-6 through 20-9 |
| 12 | Chapter 21—Omit Sections 21-4 and 21-7.1   |
| 13 | Chapter 22—Omit Sections 22-6, 22-8, and 22-9<br>Chapter 23—Omit Sections 23-3.3 through 23-6                    |
| 14 | Chapter 24—Omit Sections 24-4.1, 24-6.1, 24-9, 24-10, and 24-11  |

Week	Electronics
15	Chapter 28—Omit Sections 28-12 and 28-13
16	Chapter 29

- 4 For a one-semester dc/ac analysis course that concentrates on areas such as network theorems, magnetic circuits, exponential equations for  $L$  and  $C$  circuits, and complex numbers and is designed to follow the course in No. 3 above, the following chapters, sections, and appendixes are recommended. (It is assumed that coverage of sections omitted in the first course will be accompanied by a general review of pertinent material in the appropriate chapter.)

Week	Reading Assignments
1	General review plus Chapter 4
2	Chapter 7
3,4,5	Chapter 10 and Appendix D
6	Review plus Sections 11-11, 11-14, and 11-15 plus Appendix L
7	Review of Chapter 14 plus Appendixes E, G, and H

- 8 Chapter 16
- 9 Review of Chapter 17 plus Sections 17-2,  
17-5.3, and 17-5.4  
Review of Chapter 18 plus Sections 18-1.4  
and 18-6
- 10 Sections 19-4, 19-6.1, 19-6.2, and 19-10  
Sections 20-4, 20-6 through 20-9 plus Ap-  
pendix J
- 11 Sections 21-4 and 21-7.1 plus Appendix K  
Sections 22-6, 22-8, and 22-9
- 12 Sections 23-3.3 through 23-6 plus  
Appendix M  
Review Chapter 24 Plus Sections 24-4.1,  
24-6.1, 24-9, 24-10, and 24-11
- 13,14 Chapter 25
- 15 Chapter 26
- 16 Chapter 27

Individual needs vary from one instructor and course to another so that many variations of the above are possible. For example, Chapter 25 on complex num-

bers may appear more logically (for some) before reactance. Or they may feel it is too advanced and omit it altogether.

It is assumed that a laboratory session constitutes part of each semester course, using a minimum of three hours lecture and three hours laboratory per week. Topics have been arranged with this in mind so that, for example, Chapter 16 on the oscilloscope precedes capacitance and inductance. This means that the oscilloscope can be used in the laboratory experiments on these two topics, allowing the observation and measurement of time constant.

Students can check their own progress by doing the review questions, self-examinations, and problems. In general, problems become more difficult toward the end of each chapter, and even more challenging ones are found among the even numbers. A Solutions Manual for all problems is available to instructors.

A.M.



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