



# **ELECTRONICS**

**A Contemporary Approach**

**WILLIAM H. GOTHMANN**

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# **ELECTRONICS:**

## **A Contemporary Approach**

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**ELECTRONICS:**  
**A Contemporary Approach**

To:  
*Myrna, Sue,*  
*Bud, and Mark*

By wisdom a house is built,  
And by understanding it is established,  
And by knowledge the rooms are filled  
With all precious and pleasant riches.

*Solomon*



# PREFACE

A popular song once lamented, "The Old, Gray Mare, She Ain't What She Used To Be." Like the mare, electronics is very different now from what it was a scant ten years ago. The new and imaginative areas of citizens'-band radio, microprocessors, and electrooptical techniques have expanded what used to be a purely communications industry into one encompassing such diverse uses as monitoring patients in hospitals and processing data electronically. These revolutionary and exciting developments have been integrated into this beginning electronics text together with the more traditional subjects so that students can be well grounded in all phases of the industry. Hardware such as integrated circuits and light-emitting diodes appear alongside tubes, transistors, and neon lamps. Techniques such as wire wrapping and printed-circuit-card fabrication are presented along with the traditional soldering and cable-wrapping skills. The goal is to introduce the reader to the full range of contemporary basic concepts in both communications and industrial electronics. As such, the book is suitable for a first course in electronic technology programs.

Not only must our subjects be contemporary, but our teaching methods must be updated to use the power of the hand-held calculator. Whereas complex numbers were once avoided because of the lengthy arithmetic required, this text uses them extensively as a tool for greater understanding of alternating current. In addition,  $RC$  time constants are treated more mathematically than graphically, reflecting the change in approach used by most instructors. Similarly, determinants are used in the solution of simultaneous equations, recognizing the ease with which they can be worked on the calculator. A section on determinants is included in the Appendix for students who are unfamiliar with them. Finally, four-place accuracy is used in all calculations so that students can check to make certain their methods are correct.

The classroom must also be the governing factor in the order of presentation. Two fundamental arrangements could have been used: the theoretical and the functional.

The theoretical approach ignores the practical realities of the classroom by assuming that no knowledge of a particular subject is needed until a point is reached at which the entire subject can be revealed. It is a fact of life that the functional approach is used within the classroom; material is presented in the order in which it can be learned most easily. This text was written for such a classroom situation. For example, the operation of meters is introduced very early to enable students to start to work immediately in the laboratory. Then, much later, their internal construction is examined. In a similar manner, resistors and their color codes are introduced very early. The attempt has been to order the subjects as the classroom demands rather than as the author finds convenient.

The text is divided into three logical major parts, corresponding to those used in most technology programs:

Part I: Direct Current

Part II: Alternating Current

Part III: Active Elements

This enables the student to step back and view the forest while keeping the trees in sight.

Part I introduces the principles of direct current. Chapter 7 is rather unique in an electronics text, for it is devoted to understanding those parts and pieces of hardware which we all tend to ignore. It was included at the request of instructors who felt their graduates to be unduly weak in this area.

Part II introduces the principles of alternating current. The opening discussion on magnetism is quite detailed, including material about bubble memories. Additionally, this part includes:

1. RMS of rectangular waveforms (Chapter 11).
2. Polar-rectangular methods on the calculator (Chapter 12).
3. An extensive discussion of dielectrics (Chapter 15).
4. Application of network theorems to ac problems (Chapter 17).
5. A discussion of active filters (Chapter 19).

Part III, Active Elements, provides a survey of transistors, integrated circuits, and vacuum tubes. The discussion is more qualitative than quantitative, to enable the student to receive a good overview of these subjects.

This text could not have been written without the help of the outstanding faculty at Spokane Community College and Spokane Falls Community College. Henry Peden's detailed review of the entire manuscript provided many constructive comments for improving its technical accuracy. In addition, the photographs supplied by George Ruple of SCC, Steve Vento of American Sign and Indicator, Robert Gilchrist, and the many manufacturers greatly improve its appeal and understandability. The

sketches drawn by Jeanette Kirishian of SFCC add that touch of humor that enables the student to remember the concepts.

Finally, I sincerely appreciate the support, encouragement, and constructive criticism of my wife, Myrna, during the preparation of the manuscript.

*Spokane, WA.*

**BILL GOTHMANN**



# INTRODUCTION

The electronics industry is perhaps the fastest growing, most dynamic industry in the world today, serving us in such diverse areas as electronic ignition in cars, citizens-band radio, and electronic data processing. It is truly a varied field, requiring a sound knowledge of basic principles used in electronics. This text is designed to satisfy this goal. As such it is divided into three major parts:

**PART I: Direct Current**

**PART II: Alternating Current**

**PART III: Active Elements**

PART I discusses a type of circuit whereby electrical charges flow only in one direction along a wire. Examples of such circuits include the automobile electrical system and the portable calculator.

PART II, Alternating Current, introduces a type of circuit whereby the direction of charge flow along a wire reverses direction periodically. Radio and television transmission uses this type of circuit, as does ordinary 120-volt wiring in our houses and businesses.

PART III introduces devices used to amplify, that is, to take a small electronic signal and boost it into a large signal. These devices—transistors, vacuum tubes, and integrated circuits—are used daily in our radios, calculators, and even our watches.

Direct current, alternating current, and active elements form the basis for all electronics. Turn the page and enter this challenging, exciting world.



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# PART I

## DIRECT CURRENT

This part of the text is devoted to those electrical charges that refuse to be deterred in their direction along a wire. Such unidirectional behavior in the world of charges is called *direct current* (dc). In our study of this phenomenon we shall first examine the structure of matter, then the principles and laws governing dc flow. Next, we shall apply these laws to the circuits typically encountered in electronic equipment. We shall then examine the hardware used in building such equipment, some rather sophisticated methods of analyzing circuits, and, finally, the circuits used to form the meters by which we measure direct current. The chapters within this part include:

1. Introduction to Electronics
2. Current, Voltage, and Resistance
3. Ohm's Law
4. Series Circuits
5. Parallel Circuits
6. Series-Parallel Circuits
7. System Hardware
8. Network Analysis
9. Direct-Current Meters