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0521664438 - Electronic Concepts: An Introduction
Jerrold H. Krenz
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ELECTRONIC CONCEPTS

Electronic Concepts is a clear, self-contained introduction to modern microelectronics. Analog and digital circuits are stressed equally from the outset, and the applications of particular devices and circuits are described within the context of actual electronic systems. A combination of bottom–up and top–down approaches is used to integrate this treatment of devices, circuits, and systems.

The author begins with an overview of several important electronic systems, discussing in detail the types of signals that circuits are used to process. In the following chapters he deals with individual devices such as the bipolar junction transistor and the metal-oxide semiconductor field-effect transistor. For each device he presents a brief physical description and demonstrates the use of different models in describing the device's behavior in a particular circuit application. Throughout the book, he uses SPICE computer simulations extensively to supplement analytic descriptions.

The book contains over 500 circuit diagrams and figures, over 400 homework problems, and over 100 simulation and design exercises. It includes many worked examples and is an ideal textbook for introductory courses in electronics. It can also be used for self-study. Laboratory experiments related closely to the material covered in the book are available via the World Wide Web.

Jerrold Krenz received his Ph.D. from Stanford University and is Associate Professor of Electrical and Computer Engineering at the University of Colorado, Boulder. He is the author of several books, including *Microelectronic Circuits: A Laboratory Approach* and *An Introduction to Electrical Circuits and Electronic Devices: A Laboratory Approach*.

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AN INTRODUCTION

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PREFACE

The field of electronics or microelectronics today encompasses a vast quantity of knowledge and practice. The topics that can be covered in a basic course must, by necessity, be limited to avoid a mere encyclopedic cataloging of various electronic circuits and systems. There are, however, a set of underlying concepts that one needs to grasp to understand electronics. It is the goal of the author to provide students and instructors with an accessible treatment of those modern electronic concepts along with appropriate applications. Applications are considered essential to grasp the utility of general concepts as well as to appreciate their limitations. The approach used in the text is to cover a limited number of topics well, as opposed to a cursory coverage of a very wide range of topics that may do little more than leave one with an extensive vocabulary.

The text provides more than adequate material for a one-semester, junior-level electronics course. A good working knowledge of linear circuits along with a reasonable understanding of calculus and physics is required. Although there is a progression in the complexity of the material covered, the text provides a flexibility in selecting the material to cover. The author has attempted to provide sufficient descriptive material to indicate not only what is being done but also to show how a particular circuit is used. Examples with detailed solutions utilizing analytic solutions and computer simulations conclude most sections. In addition, numerous references are cited to allow the interested student to learn more about a particular topic.

An unique feature of the book is its introductory chapter, which provides an overview of several electronic systems. This chapter makes the learning task more interesting for the students and serves to introduce them to the signals that electronic circuits are used to process. Electronic circuits were developed to fulfill particular needs. At the same time, the evolution of electronic systems depended on what could be done with the electronic devices then available. The text provides a combination of a top–down and a bottom–up approach. Systems are considered as well as basic physical concepts that are necessary for understanding devices.

The text provides a transition from the coverage of introductory circuit theory courses that tend to deal only with two-terminal linear devices for which simple

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circuit models are valid ($v = iR$, etc.). Although, for circuit theory, it is seldom necessary to distinguish between the model and the device it describes, this is not the case for electronic devices. In *Electronic Concepts*, a student is gradually introduced to the use of different models used for a single device. The particular model employed depends on the nature of the circuit in which the device is used and the signals involved. The treatment of circuits with nonlinear devices and with three (and at times four) terminals is recognized as a significant conceptual leap for students.

The second chapter, The Semiconductor Junction Diode, includes a brief qualitative discussion of semiconductor physics. Although it is recognized that an in-depth knowledge of semiconductor physics is very important, the author feels that this can best be accomplished in a concurrent or subsequent theory course. *Electronic Concepts* discusses electrons and holes moving as the result of potential differences, thereby providing a basis for an intuitive understanding of semiconductor devices. Load lines, the diode equation, and various diode models used to approximate the behavior of diodes are introduced. The basic principles of photovoltaic cells and light-emitting diodes are discussed as well as important applications.

The bipolar junction transistor is introduced in Chapter 3 before the coverage of field-effect devices in Chapter 4. Treating field-effect devices first does have a certain appeal because, for some applications, the field-effect models are simpler than those of bipolar junction transistors. However, the bipolar junction transistor is a direct extension of the junction diode, and this type of transistor is considerably more convenient for doing laboratory experiments. An understanding of individual semiconductor devices, as viewed from their terminals, as well as the concepts related to using devices for amplification and switching is stressed.

Chapter 4 provides a brief qualitative physical discussion of MOSFET devices and introduces approximate analytical expressions for their terminal behavior. Although the behavior of analog circuits based on the small-signal behavior of devices is covered, the main thrust of this chapter is digital circuits. Both the static and dynamic behaviors of logic gates using device configurations suitable for integrated circuits are determined. Following a treatment of bistable circuits, semiconductor memories are discussed.

Negative feedback, along with operational amplifiers, is the subject of Chapter 5. The feedback nature of operational amplifier circuits is stressed because the frequently used "ideal op amp" treatment of basic circuit texts generally glosses over the feedback nature of op amp circuits. Negative feedback, although introducing a higher order of complexity, is shown to offer many improvements over circuits without feedback. It is also emphasized that if feedback is not used properly, undesirable behavior can occur. Analog design techniques using op amps are highlighted in this chapter.

A concluding chapter on electronic power supplies treats rectifiers, filters, electronic regulators, and batteries. A knowledge of this material, all too frequently omitted in basic electronics courses, is necessary for the design of nearly all electronic systems. This chapter may be covered immediately after Chapter 2 if the electronic regulator section is omitted.

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Appendix A on the fabrication of integrated circuits carries one beyond the electronics circuits emphasis of the text. It provides a glimpse of the physical and chemical techniques used in the fabrication process and a perspective on the actual physical structures and sizes of devices. Appendix B, The Design Process, carries through the design of a few sample electronic circuits. Explanations are provided for each step so that the student may appreciate the rationale for the design decisions.

Computer simulations are used throughout the text. It is assumed that students are familiar with SPICE, that is, that they have used it in a linear circuits course (if not, numerous basic reference texts are available). Circuit files, common for all versions of SPICE, are included for all simulation examples. Although the text uses Probe (MicroSim) graphs, similar presentations can be obtained with other programs.

Problems requiring analytical solutions as well as computer simulations are also included. There are considerably more problems and simulations than can be used for a one-semester course, and thus instructors can vary assignments from semester to semester and reduce the use of solutions from previous classes. Computer simulations are limited to circuits that can be run on personal computers with the student version of the PSPICE program. Open-ended, design-type exercises are also included.

Laboratory experiments that relate directly to the theory of each chapter are also available on the World Wide Web:
http://www.cup.org/titles/66/0521662826.html

A portable document format (.pdf extension) is used for the experiments so that they may readily be downloaded and printed. Detailed experimental steps are employed to guide a student through a set of measurements and observations, and minimum effort is required on the part of the instructor. Alternatively, portions of experiments may be used for classroom demonstrations.

Boulder, CO

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