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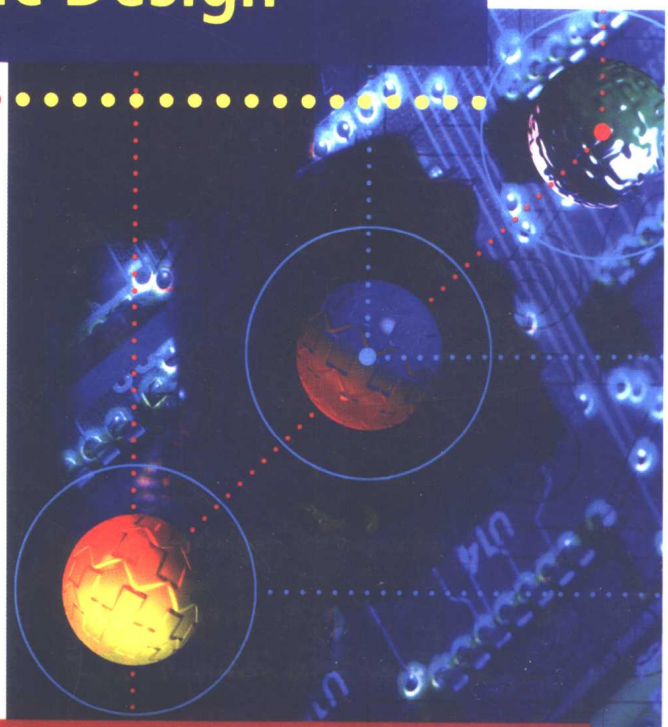
逻辑设计基础

（英文版 · 第5版）

5th Edition

Fundamentals of Logic Design



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Charles H. Roth, Jr. 著
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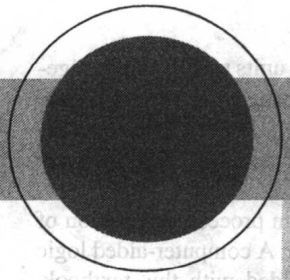

Preface

After studying this text, you should be able to apply switching theory to the solution of logic design problems. This means that you will learn both the basic theory of switching circuits and how to apply it. After a brief introduction, you will study Boolean algebra, which is the basic mathematical tool needed to analyze and synthesize an important class of switching circuits. Starting from a problem statement, you will learn to design circuits of logic gates that have a specified relationship between signals at the input and output terminals. Then you will study the logical properties of flip-flops, which serve as memory devices in sequential switching circuits. By combining flip-flops with circuits of logic gates, you will learn to design counters, adders, sequence detectors, and similar circuits. You will also study the VHDL hardware description language and its application to the design of combinational logic, sequential logic, and simple digital systems.

This new edition offers a number of improvements over the fourth edition. Material in the text has been reorganized to provide a better teaching sequence, and obsolete material has been removed. The chapter on latches and flip-flops has been rewritten. Greater emphasis is placed on the use of programmable logic devices (PLDs), including programmable gate arrays and complex PLDs. New exercises and problems have been added to every unit, and several sections have been rewritten to clarify the presentation. Three chapters on the VHDL hardware description language have been added, and more emphasis is placed on the role of simulation and computer-aided design of logic circuits.

This text is designed so that it can be used in either a standard lecture course or in a self-paced course. In addition to the standard reading material and problems, study guides and other aids for self-study are included in the text. The content of the text is divided into 20 study units. These units form a logical sequence so that mastery of the material in one unit is generally a prerequisite to the study of succeeding units. Each unit consists of four parts. First, a list of objectives states precisely what you are expected to learn by studying the unit. Next, the study guide contains reading assignments and study questions. As you work through the unit, you should write out the answers to these study questions. The text material and problem set that follow are similar to a conventional textbook. When you complete a unit, you should review the objectives and make sure that you have met them.

The study units are divided into three main groups. The first 9 units treat Boolean algebra and the design of combinational logic circuits. Units 11 through 16, 18 and 19 are mainly concerned with the analysis and design of clocked sequential logic circuits, including circuits for arithmetic operations. Units 10, 17, and 20 introduce the VHDL hardware description language and its application to logic design.

Since the computer plays an important role in the logic design process, integration of computer usage into the first logic design course is very important. A computer-aided logic design program, called *LogicAid,* is included on the CD provided with this textbook. *LogicAid* allows the student easily to derive simplified logic equations from minterms, truth tables, and state tables. This relieves the student of some of the more tedious computations and permits the solution of more complex design problems in a shorter time. *LogicAid* also provides tutorial help for Karnaugh maps and derivation of state graphs.

Several of the units include simulation or laboratory exercises. These exercises provide an opportunity to design a logic circuit and then test its operation. The *SimUaid* logic simulator, provided on the CD, may be used to verify the logic designs. The lab equipment required for testing either can be a breadboard with integrated circuit flip-flops and logic gates or a circuit board with a programmable logic device. If such equipment is not available, the lab exercises can be simulated with *SimUaid* or just assigned as design problems. This is especially important for Units 8, 16, and 20 because the comprehensive design problems in these units help to review and tie together the material in several of the preceding units.

As integrated circuit technology continues to improve to allow more components on a chip, digital systems continue to grow in complexity. Design of such complex systems is facilitated by the use of a hardware description language such as VHDL. This text introduces the use of VHDL in logic design and emphasizes the relationship between VHDL statements and the corresponding digital hardware. VHDL allows digital hardware to be described and simulated at a higher level before it is implemented with logic components. Computer programs for synthesis can convert a VHDL description of a digital system to a corresponding set of logic components and their interconnections. Even though use of such computer-aided design tools helps to automate the logic design process, we believe that it is important to understand the underlying logic components and their timing before writing VHDL code. By first implementing the digital logic manually, students more fully can appreciate the power and limitations of VHDL.

This text is written for a first course in the logic design of digital systems. It is written on the premise that the student should understand and learn thoroughly certain fundamental concepts in a first course. Examples of such fundamental concepts are the use of Boolean algebra to describe the signals and interconnections in a logic circuit, use of systematic techniques for simplification of a logic circuit, interconnection of simple components to perform a more complex logic function, analysis of a sequential logic circuit in terms of timing charts or state graphs, and use of a control circuit to control the sequence of events in a digital system.

The text attempts to achieve a balance between theory and application. For this reason, the text does not overemphasize the mathematics of switching theory; however, it does present the theory that is necessary for understanding the fundamental concepts of logic design. After completing this text, the student should be prepared for a more advanced digital systems design course that stresses more intuitive concepts like the development of

algorithms for digital processes, partitioning of digital systems into subsystems, and implementation of digital systems using currently available hardware. Alternatively, the student should be prepared to go on to a more advanced course in switching theory that further develops the theoretical concepts that have been introduced here.

Although the technology used to implement digital systems has changed significantly since the first edition of this text was published, the fundamental principles of logic design have not. Truth tables and state tables still are used to specify the behavior of logic circuits, and Boolean algebra is still a basic mathematical tool for logic design. Even when programmable logic devices are used instead of individual gates and flip-flops, reduction of logic equations is still desirable in order to fit the equations into smaller PLDs. Making a good state assignment is still desirable, because without a good assignment, the logic equations may require larger PLDs.

The text is suitable for both computer science and engineering students. Material relating to circuit aspects of logic gates is contained in Appendix A so that this material can conveniently be omitted by computer science students or other students with no background in electronic circuits. The text is organized so that Unit 6 on the Quine-McCluskey procedure may be omitted without loss of continuity. The three units on VHDL can be studied in the normal sequence, studied together after the other units, or omitted entirely.

Although many texts are available in the areas of switching theory and logic design, this text was originally developed to meet the needs of a self-paced course in which students are expected to study the material on their own. Each of the units has undergone extensive class testing in a self-paced environment and has been revised based on student feedback.

Study guides and text material have been expanded as required so that students can learn from the text without the aid of lectures and so that almost all of the students can achieve mastery of all of the objectives. Supplementary materials were developed as the text was being written. An instructor's manual is available that includes suggestions for using the text in a standard or self-paced course, quizzes on each of the units, and suggestions for laboratory equipment and procedures. The instructor's manual also contains solutions to problems, to unit quizzes, and to lab exercises.

To be effective, a book designed for self-study cannot simply be written. It must be tested and revised many times to achieve its goals. I wish to express my appreciation to the many professors, proctors, and students who participated in this process. Special thanks go to Dr. David Brown, who worked with me in teaching the self-paced course, and who made many helpful suggestions for improving the text. I am especially grateful to graduate teaching assistant, Mark Story, who developed many new problems and solutions for this edition and who offered many suggestions for improving the consistency and clarity of the presentation.

How to Use This Book for Self-Study

If you wish to learn all of the material in this text to mastery level, the following study procedures are recommended for each unit:

1. Read the *Objectives* of the unit. These objectives provide a concise summary of what you should be able to do when you complete study of the unit.
2. Work through the *Study Guide.* After reading each section of the text, write out the answers to the corresponding study guide questions. In many cases, blank spaces are left in the study guide so that you can write your answers directly in this book. By doing this, you will have the answers conveniently available for later review. The study guide questions generally will help emphasize some of the important points in each section or will guide you to a better understanding of some of the more difficult points. If you cannot answer some of the study guide questions, this indicates that you need to study the corresponding section in the text more before proceeding. The answers to selected study guide questions are given in the back of this book; answers to the remaining questions generally can be found within the text.
3. Several of the units (Units 3, 5, 6, 11, 13, 14, and 18) contain one or more programmed exercises. Each programmed exercise will guide you step-by-step through the solution of one of the more difficult types of problems encountered in this text. When working through a programmed exercise, be sure to write down your answer for each part in the space provided before looking at the answer and continuing with the next part of the exercise.
4. Work the assigned *Problems* at the end of the unit. Check your answers against those at the end of the book and rework any problems that you missed.
5. Reread the *Objectives* of the unit to make sure that you can meet all of them. If in doubt, review the appropriate sections of the text.
6. If you are using this text in a self-paced course, you will need to pass a readiness test on each unit before proceeding with the next unit. The purpose of the readiness test is to make sure that you have mastered the objectives of one unit before moving on to the next unit. The questions on the test will relate directly to the objectives of the unit, so that if you have worked through the study guide and written out answers to all of the study guide questions and to the problems assigned in the study guide, you should have no difficulty passing the test.

Brief Contents

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