Preface

Purpose of the Text

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.

Contents of the Text

After studying this text, students should be able to apply switching theory to the solution of logic design problems. They will learn both the basic theory of switching circuits and how to apply it. After a brief introduction to number systems, they will study switching algebra, a special case of Boolean algebra, which is the basic mathematical tool needed to analyze and synthesize an important class of switching

circuits. Starting from a problem statement, they will learn to design circuits of logic gates that have a specified relationship between signals at the input and output terminals. Then they 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, they will learn to design counters, adders, sequence detectors, and similar circuits. They will also study the VHDL hardware description language and its application to the design of combinational logic, sequential logic, and simple digital systems.

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 can more fully appreciate the power and limitations of VHDL.

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 (PLDs) 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.

Strengths of the Text

Although many texts are available in the areas of switching theory and logic design, 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. Each of the units has undergone extensive class testing in a self-paced environment and has been revised based on student feedback.

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.

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.

Supplements and Resources

This book comes with support materials for both the instructor and the student. The supplements are housed on the book's companion website. To access the additional course materials, please visit http://login.cengage.com.

Instructor Resources

An instructor's solution manual (ISM) 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.

The ISM is available online via a secure, password-protected Instructor's Resource Center at http://login.cengage.com. The Instructor's Resource Center also includes Lecture Note PowerPoints and Image Banks for this title.

Student Resources

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 that accompanies this text. *LogicAid* allows the student to easily 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, also available on the book's accompanying 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.

The DirectVHDL software on the CD provides a quick way to check and simulate VHDL descriptions of hardware. This software checks the syntax of the VHDL code as it is typed in so that most syntax errors can be corrected before the simulation phase.

Changes from Previous Editions

The text has evolved considerably since the fifth edition. Programmable logic and the VHDL hardware description language were added, and an emphasis was placed on the role of simulation and computer-aided design of logic circuits. The discussion of VHDL, hazards, latches, and one-hot state assignments was expanded. Numerous problems were added. Several additional changes have been made for the seventh edition. The discussion of number systems was reorganized so that one's complement number systems can be easily omitted. In the unit on Boolean algebra, the laws of switching algebra are first derived using switch networks and truth tables; these are used to define Boolean algebra and, then, further theorems of Boolean algebra are derived that are useful in simplifying switching algebra expressions. The discussion of adders is expanded to include carry-lookahead adders. Alternative implementations of multiplexers are included, as is a discussion of active high and active low signals. Other types of gated latches are discussed, and a brief introduction to asynchronous sequential circuits is included. There is more discussion of incompletely specified state tables and how they may occur, and reducing incompletely specified state tables is briefly discussed. Problems have been added throughout the book with an emphasis on more challenging problems than the typical exercises. In addition, the logic design and simulation software that accompanies the text has been updated and improved.

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