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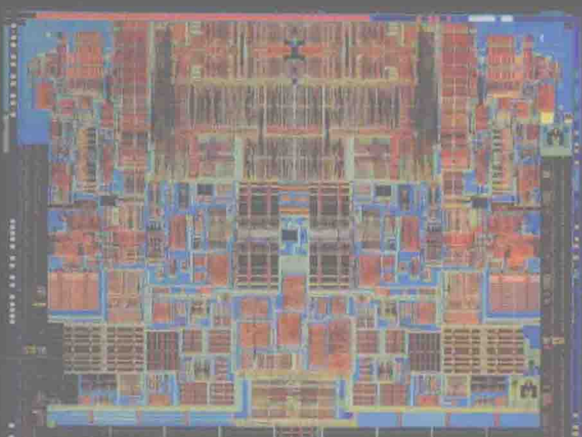
逻辑与计算机设计基础

（英文版·第4版）



Logic and Computer Design Fundamentals

Fourth Edition

M. Morris Mano
加州大学洛杉矶分校
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Preface

The objective of this text is to serve as a cornerstone for the learning of logic design, digital system design, and computer design by a broad audience of readers. This fourth edition marks the decade point in the evolution of the text contents. Beginning as an adaptation of a previous book by the first author in 1997, it continues to offer a unique combination of logic design and computer design principles with a strong hardware emphasis. Over the years, the text has followed industry trends by adding new material such as hardware description languages, removing or de-emphasizing material of declining importance, and revising material to track changes in computer technology and computer-aided design.

In the fourth edition, revisions address pedagogical considerations as well as industrial trends. Sixty "real world" examples and problems, most drawn from design problems for products encountered in contemporary day-to-day life, motivate interest and provide practice in solution formulation. Changes in chapter organization permit instructors to more easily tailor the degree of technology coverage, accommodating both electrical and computer engineering and computer science audiences.

The organizational changes begin with the combining of the introduction to design from Chapter 3 and the functional block material from Chapter 4 into a new Chapter 3. The design science content from the old Chapter 3 is now distributed over multiple chapters on an "as needed" basis and is accompanied by illustrations. Hardware description language coverage for combinational circuits has been combined in Chapter 4 with that for arithmetic circuits to balance chapter size. Material on technology from the old Chapter 3, including timing and programmable logic, appears in a new Chapter 6 and can be selectively covered and scheduled by the instructor as appropriate for the course syllabus. The placement of this material in Chapter 6 permits earlier coverage of sequential circuits for those with lesser technology-related needs and provides the more extensive background needed for some of the topics covered. Further, technology topics fit better within digital system design rather than within basic logic design material presented earlier in the text. Chapter 6 also contains new information on CMOS circuits and asynchronous interaction between systems including synchronization of inputs and metastability.

Chapter 8 has been eliminated along with the algorithmic state machine (ASM) to streamline the treatment of design of complex sequential circuits and control units. Concepts from Chapter 8 are split between Chapter 5 (Sequential Circuits) and Chapter 7 (Registers and Register Transfers). A new state machine diagram notation replaces the ASM. The state machine diagram is modeled after the traditional state diagram and graphically represents much of the modeling flexibility inherent in hardware description languages. Further, in Chapter 7, the design procedure for doing combined datapath and control unit design is formalized and illustrated.

Offering integrated coverage of both digital and computer design, this edition of *Logic and Computer Design Fundamentals* features a strong emphasis on fundamentals underlying contemporary design. Understanding of the material is supported by clear explanations and a progressive development of examples ranging from simple combinational applications to a CISC architecture built upon a RISC core. A thorough coverage of traditional topics is combined with attention to computer-aided design, problem formulation, solution verification, and the building of problem-solving skills. Flexibility is provided for selective coverage of logic design, digital system design, and computer design topics, and for coverage of hardware description languages (none, VHDL, or Verilog®). Aside from the organizational and content changes describe thus far, other updates in the Fourth Edition include: (1) a brief introduction to embedded systems, (2) illustration of practical computer-aided logic optimization methods as used in Espresso, (3) replacement of a CRT display example with an LCD screen example, and (4) an updated Architectural Innovations section including multiple CPU microprocessors.

With these revisions, chapters 1 through 5 of the book treat logic design, chapters 6 through 8 deal with digital systems design and chapters 9 through 13 focus on computer design. This arrangement provides solid digital system design fundamentals while accomplishing a gradual, bottom-up development of fundamentals for use in top-down computer design in later chapters. Summaries of the topics covered in each chapter follow.

Chapter 1—Digital Systems and Information This chapter introduces digital computers, embedded systems, and information representation including number systems, arithmetic, and codes.

Chapter 2—Combinational Logic Circuits This chapter deals with gate circuits and their types and basic ideas for their design and cost optimization. Concepts include Boolean algebra, algebraic and Karnaugh map optimization, the Espresso algorithm as a pragmatic CAD optimization tool, and multilevel optimization.

Chapter 3—Combinational Logic Design This chapter begins with an overview of a contemporary logic design process. The details of steps of the design process including problem formulation, logic optimization, technology mapping to NAND and NOR gates, and verification are covered for combinational logic design examples. In addition, the chapter covers the functions and building blocks of combinational design including enabling and input-fixing, decoding, encoding, code conversion, selecting, and distributing, and their implementations.

Chapter 4—Arithmetic Functions and HDLs This chapter deals with arithmetic functions and their implementations. Beyond number representation for arithmetic, addition, subtraction, and incrementing, decrementing, filling, extension and shifting are described and implemented. Synthesis and hardware description languages (HDLs) are introduced and Verilog and VHDL are presented for describing of combinational logic from Chapter 3 and arithmetic logic from this chapter.

Chapter 5—Sequential Circuits This chapter covers sequential circuit analysis and design. Latches, master-slave flip-flops and edge-triggered flip-flops are covered with emphasis on the D type. Other types of flip-flops (S-R, J-K and T), which are used less frequently in modern designs, are covered briefly. Emphasis is placed on state machine diagram and state table formulation. A complete design process for sequential circuits including specification, formulation, state assignment, flip-flop input and output equation determination, optimization, technology mapping, and verification is developed. A graphical state machine diagram model that represents sequential circuits too complex to model with a conventional state diagram is presented and illustrated by two real world examples. The chapter concludes with VHDL and Verilog descriptions of a flip-flop and a sequential circuit.

Chapter 6—Selected Design Topics This chapter presents topics focusing on various aspects of underlying technology including the MOS transistor and CMOS circuits, delay and timing for gates, combinational and sequential circuits, asynchronous interactions between circuits, and programmable logic technologies. The asynchronous interactions section includes coverage of synchronization of asynchronous inputs and metastability. Programmable logic covers read-only memories, programmable logic arrays and programmable array logic.

Chapter 7—Registers and Register Transfers This chapter covers registers and their applications. Shift register and counter design are based on the combination of flip-flops with functions and implementations introduced in the Chapters 3 and 4. Only the ripple counter is introduced as a totally new concept. Register transfers are considered for both parallel and serial designs and time-space tradeoffs are discussed. A section focuses on register cell design for multi-function registers that performing multiple operations. A process for the integrated design of datapaths and control units using register transfer statements and state machine diagrams is introduced and illustrated by two real world examples. Verilog and VHDL descriptions of selected register types are introduced.

Chapter 8—Memory Basics This chapter introduces static random access memory (SRAM) and dynamic random access memory (DRAM), and basic memory systems. It also describes briefly various distinct types of SRAMs.

Chapter 9—Computer Design Basics This chapter covers register files, function units, datapaths, and two simple computers: a single-cycle computer and a multiple-cycle computer. The focus is on datapath and control unit design formulation concepts applied to implementing specified instructions and instruction sets in single-cycle and multiple-cycle designs.

Chapter 10—Instruction Set Architecture introduces many facets of instruction set architecture. It deals with address count, addressing modes, architectures, and the types of instructions and presents floating-point number representation and operations. Program control architecture is presented including procedure calls and interrupts.

Chapter 11—RISC and CISC Processors This chapter covers high-performance processor concepts including a pipelined RISC processor, and a CISC processor. The

CISC processor, by using microcoded hardware added to a modification of the RISC processor, permits execution of the CISC instruction set using the RISC pipeline, an approach used in contemporary CISC processors. Also, sections describe high-performance CPU concepts and architecture innovations including two examples of multiple CPU microprocessors.

Chapter 12—Input-Output and Communication This chapter deals with data transfer between the CPU and memory, input-output interfaces and peripheral devices. Discussions of a keyboard, a Liquid Crystal Display (LCD) screen, and a hard drive as peripherals are included, and a keyboard interface is illustrated. Other topics range from serial communication, including the Universal Serial Bus (USB), to interrupt system implementation.

Chapter 13—Memory Systems has a particular focus on memory hierarchies. The concept of locality of reference is introduced and illustrated by consideration of the cache/main memory and main memory/hard drive relationships. An overview of cache design parameters is provided. The treatment of memory management focuses on paging and a translation lookaside buffer supporting virtual memory.

In addition to the text itself, a Companion Website and an Instructor's Manual are provided. Companion Website (http://www.prenhall.com/mano) content includes the following: 1) reading supplements including new material and material deleted from prior editions, 2) VHDL and Verilog source files for all examples, 3) links to computer-aided design tools for FPGA design and HDL simulation, 4) solutions for about one-third of all text Chapter problems, 5) errata, 6) PowerPoint® slides for Chapters 1 through 9, 7) projection originals for complex figures and tables from the text, and 8) site news sections for students and instructors pointing out new material, updates, and corrections. Instructors are encouraged to periodically check the instructor's site news so that they are aware of site changes. **Instructor's Manual** content includes suggestions for use of the book and all problem solutions. On-line access to this manual is available from Prentice Hall to instructors at academic institutions who adopt the book for classroom use. The suggestions for use provide important detailed information for navigating the text to fit with various course syllabi.

Because of its broad coverage of both logic and computer design, this book serves several different objectives in sophomore through junior level courses. Chapters 1 through 10 with selected sections omitted, provide an overview of hardware for computer science, computer engineering, electrical engineering or engineering students in general in a single semester course. Chapters 1 through 5 possibly with selected parts of 6 through 8 give a basic introduction to logic design, which can be completed in a single quarter for electrical and computer engineering students. Coverage of Chapters 1 through 8 in a semester, provides a stronger, more contemporary logic design treatment. The entire book, covered in two quarters, provides the basics of logic and computer design for computer engineering and science students. Coverage of the entire book with appropriate supplementary material or a laboratory component can fill a two-semester sequence in logic design and computer architecture. Due to its moderately paced treatment of a wide range of topics, the book is ideal for self-study by engineers and computer scientists. Finally, all of these various objectives can also benefit from use of reading supplements provided on the Companion Website.

During the preparation of the fourth edition, we have sought out the views of many instructors using prior editions of this text. Over 50 instructors completed an extensive survey on the third edition content and their uses of it. In addition, Professor Bharat Bhuva, Vanderbilt University, and Professor Donald Hung, San Jose State University, provided useful feedback through written reviews of the third edition. We are very grateful to all of these instructors for their participation and their thoughtful input in guiding the preparation of the fourth edition. Particular thanks goes to Professors Katherine Compton, Mikko Lipasti, Kewal Saluja, and Leon Shohet, and Faculty Associate Michael Morrow, ECE, University of Wisconsin–Madison. Via focused discussions with the second author, they provided extensive comments and suggestions that greatly influenced the fourth edition content. We appreciate corrections to the third edition provided by both instructors and students, most notably, those from Professor Douglas De Boer of Dordt College. A special thanks goes to Divya Jhalani from the University of Wisconsin–Madison for her preparation of solutions to new problems in the Instructor's Manual and on the website. Our appreciation goes to all of those at Prentice Hall and elsewhere for their efforts on this edition. Notable are Editor Mike McDonald for his guidance, encouragement and support, Production Editors Dan Sandin and Irvwin Zucker for their efficiency and helpfulness with text production, and Bob Lentz for his maticulous copy-editing. Finally, a very special thanks to Val Kime for her enduring patience and understanding throughout the development of the fourth edition.

M. MORRIS MANO
CHARLES R. KIME

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