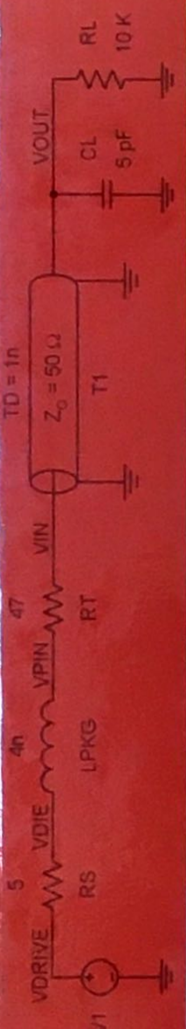
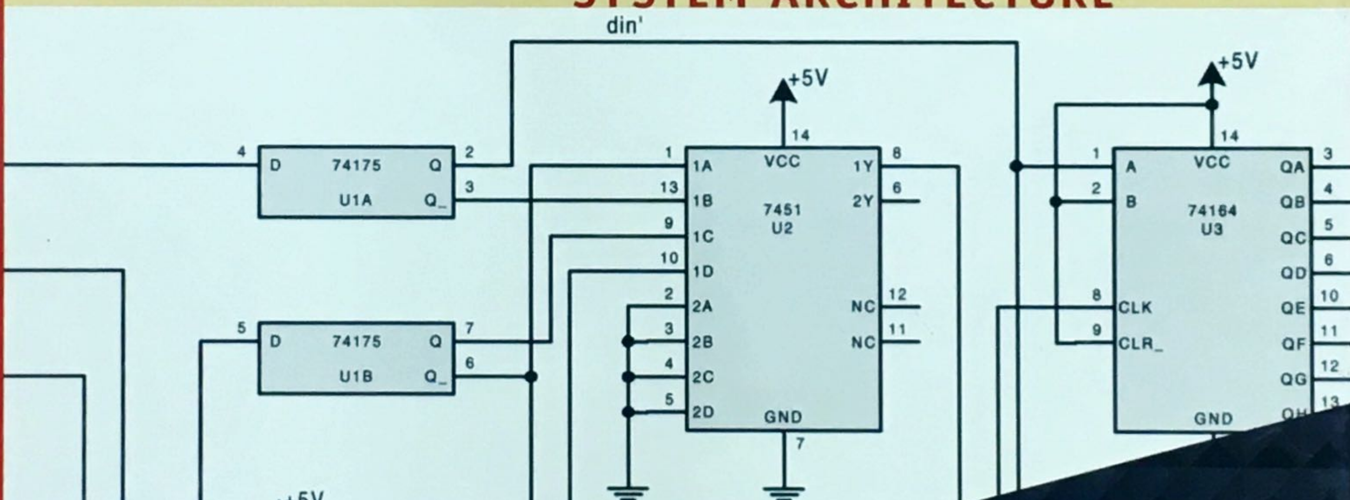
COMPLETE DIGITAL DESIGN

A COMPREHENSIVE GUIDE TO DIGITAL ELECTRONICS AND COMPUTER SYSTEM ARCHITECTURE





Real world implementation of Microprocessor-based digital systems

Broad presentation of supporting analog circuit principles

Build complete systems with basic design elements

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COMPLETE DIGITAL DESIGN

A Comprehensive Guide to Digital Electronics and Computer System Architecture

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PART 4 Digital System Design in Practice

PREFACE

Digital systems are created to perform data processing and control tasks. What distinguishes one system from another is an architecture tailored to efficiently execute the tasks for which it was designed. A desktop computer and an automobile's engine controller have markedly different attributes dictated by their unique requirements. Despite these differences, they share many fundamental building blocks and concepts. Fundamental to digital system design is the ability to choose from and apply a wide range of technologies and methods to develop a suitable system architecture. Digital electronics is a field of great breadth, with interdependent topics that can prove challenging for individuals who lack previous hands-on experience in the field.

This book's focus is explaining the real-world implementation of complete digital systems. In doing so, the reader is prepared to immediately begin design and implementation work without being left to wonder about the myriad ancillary topics that many texts leave to independent and sometimes painful discovery. A complete perspective is emphasized, because even the most elegant computer architecture will not function without adequate supporting circuits.

A wide variety of individuals are intended to benefit from this book. The target audiences include

- *Practicing electrical engineers seeking to sharpen their skills in modern digital system design.* Engineers who have spent years outside the design arena or in less-than-cutting-edge areas often find that their digital design skills are behind the times. These professionals can acquire directly relevant knowledge from this book's practical discussion of modern digital technologies and design practices.
- *College graduates and undergraduates seeking to begin engineering careers in digital electronics.* College curricula provide a rich foundation of theoretical understanding of electrical principles and computer science but often lack a practical presentation of how the many pieces fit together in real systems. Students may understand conceptually how a computer works while being incapable of actually building one on their own. This book serves as a bridge to take readers from the theoretical world to the everyday design world where solutions must be complete to be successful.
- *Technicians and hobbyists seeking a broad orientation to digital electronics design.* Some people have an interest in understanding and building digital systems without having a formal engineering degree. Their need for practical knowledge in the field is as strong as for degreed engineers, but their goals may involve laboratory support, manufacturing, or building a personal project.

There are four parts to this book, each of which addresses a critical set of topics necessary for successful digital systems design. The parts may be read sequentially or in arbitrary order, depending on the reader's level of knowledge and specific areas of interest.

A complete discussion of digital logic and microprocessor fundamentals is presented in the first part, including introductions to basic memory and communications architectures. More advanced computer architecture and logic design topics are covered in Part 2, including modern microprocessor architectures, logic design methodologies, high-performance memory and networking technologies, and programmable logic devices.

Part 3 steps back from the purely digital world to focus on the critical analog support circuitry that is important to any viable computing system. These topics include basic DC and AC circuit analysis, diodes, transistors, op-amps, and data conversion techniques. The fundamental topics from the first three parts are tied together in Part 4 by discussing practical digital design issues, including clock distribution, power regulation, signal integrity, design for test, and circuit fabrication techniques. These chapters deal with nuts-and-bolts design issues that are rarely covered in formal electronics courses.

More detailed descriptions of each part and chapter are provided below.

PART 1 DIGITAL FUNDAMENTALS

The first part of this book provides a firm foundation in the concepts of digital logic and computer architecture. Logic is the basis of computers, and computers are intrinsically at the heart of digital systems. We begin with the basics: logic gates, integrated circuits, microprocessors, and computer architecture. This framework is supplemented by exploring closely related concepts such as memory and communications that are fundamental to any complete system. By the time you have completed Part 1, you will be familiar with exactly how a computer works from multiple perspectives: individual logic gates, major architectural building blocks, and the hardware/software interface. You will also have a running start in design by being able to thoughtfully identify and select specific off-the-shelf chips that can be incorporated into a working system. A multilevel perspective is critical to successful systems design, because a system architect must simultaneously consider high-level feature trade-offs and low-level implementation possibilities. Focusing on one and not the other will usually lead to a system that is either impractical (too expensive or complex) or one that is not really useful.

Chapter 1, "Digital Logic," introduces the fundamentals of Boolean logic, binary arithmetic, and flip-flops. Basic terminology and numerical representations that are used throughout digital systems design are presented as well. On completing this chapter, the awareness gained of specific logical building blocks will help provide a familiarity with supporting logic when reading about higher-level concepts in later chapters.

Chapter 2, "Integrated Circuits and the 7400 Logic Families," provides a general orientation to integrated circuits and commonly used logic ICs. This chapter is where the rubber meets the road and the basics of logic design become issues of practical implementation. Small design examples provide an idea of how various logic chips can be connected to create functional subsystems. Attention is paid to readily available components and understanding IC specifications, without which chips cannot be understood and used. The focus is on design with real off-the-shelf components rather than abstract representations on paper.

Chapter 3, "Basic Computer Architecture," cracks open the heart of digital systems by explaining how computers and microprocessors function. Basic concepts, including instruction sets, memory, address decoding, bus interfacing, DMA, and assembly language, are discussed to create a complete picture of what a computer is and the basic components that go into all computers. Questions are not left as exercises for the reader. Rather, each mechanism and process in a basic computer is discussed. This knowledge enables you to move ahead and explore the individual concepts in more depth while maintaining an overall system-level view of how everything fits together.

Chapter 4, "Memory," discusses this cornerstone of digital systems. With the conceptual understanding from Chapter 3 of what memory is and the functions that it serves, the discussion progresses to explain specific types of memory devices, how they work, and how they are applicable to different computing applications. Trade-offs of various memory technologies, including SRAM, DRAM, flash, and EPROM, are explored to convey an understanding of why each technology has its place in various systems.