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国外高校电子信息类优秀教材

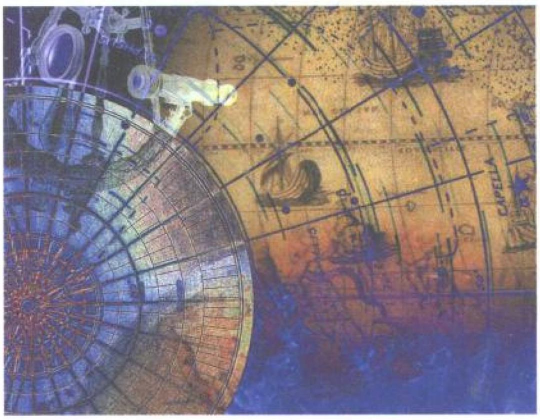
数字系统设计入门教程

——集成方法

A First Course In Digital Systems Design:

An Integrated Approach

（英文影印版）



John P. Uyemura 著

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2002

内 容 简 介

本书为国外高校电子信息类优秀教材(英文影印版)之一。

本书是数字系统入门教程,介绍了数字系统的概念、布尔代数与逻辑门、组合逻辑设计、数字硬件、VHDL 的概念、超大规模集成电路的设计,并介绍了逻辑组件和网络,最后讲述了基本的计算机体系结构。

本书可作为电气工程、计算机工程、计算机科学等专业的本科生教材,也可供相关专业技术人员参考。

A First Course In Digital Systems Design: An Integrated Approach

By John P. Uyemura

First published by Brooks/Cole, a division of Thomson Learning, United States of America

981-240-835-5

图字:01-2001-4991

图书在版编目(CIP)数据

数字系统设计入门教程——集成方法/(美)尤耶穆拉(Uyemura,J. P.)著.—影印版 —北京:科学出版社,2002

(国外高校电子信息类优秀教材)

ISBN 7-03-010129-4

Ⅰ.数… Ⅱ 尤… Ⅲ 集成电路-高等学校-教材-英文 Ⅳ.TN40

中国版本图书馆 CIP 数据核字(2002)第 007969 号

科学出版社 出版

北京东黄城根北街16号

邮政编码 100717

http //www sciencep com

新蕾印刷厂 印刷

科学出版社发行 各地新华书店经销

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2002 年 3 月第 一 版	开本:787×1092 1/16
2002 年 3 月第一次印刷	印张:32 1/4
印数:1—3 000	字数:760 000

定价:48.00 元

(如有印装质量问题,我社负责调换〈环伟〉)

Preface

This book is designed as a text for a first course in digital systems design as taken by students in electrical engineering, computer engineering, and computer sciences. It has been written to provide a new paradigm for the teaching of the subject, one that covers classical topics but also integrates modern technology into the discussion to provide the student with a real-world viewpoint of modern digital design.

Topical Coverage

A quick reading of the table of contents will verify that the "usual" topics have been included in the text. However, several non-standard chapters have been integrated into the discussion with equal emphasis. The general flow of topics follows.

Chapter 1, titled *Concepts in Digital Systems*, is a general introduction to the use of binary numbers. It provides sections on encoding and binary represention of base-10 numbers and quantities. It also introduces the concept of hierarchical design, which is propagated through the entire book. Fundamentals of *Boolean Algebra and Logic Gates* are covered in **Chapter 2**, and the principles are extended to *Combinational Logic Design* in **Chapter 3**. These three chapters provide the theoretical foundations of the subject.

Switching characteristics and delay times are critical in modern system design. These are introduced in **Chapter 4,** *Digital Hardware*. The coverage is quite broad, and the main purpose of the chapter is to illustrate the behavior of real-world electronic switching networks. This sets the stage for **Chapter 5**, *First Concepts in VHDL*, which presents the structure and main ideas of an important tool in modern design. Placing VHDL here allows the student to see how theory and physical implementations are related and also provides a mechanism for additional practice in the ideas of digital logic.

Concepts in modern VLSI design that are unique to this text are presented in Chapters 6 and 7. **Chapter 6,** *CMOS Logic Circuits,* introduces MOSFETs as basic switching elements and then teaches how CMOS logic gates are designed. Although this subject may seem a bit out of place, this is simply switch logic as realized in a modern technology. **Chapter 7,** *Silicon Chips and VLSI*, provides an entry into the field of VLSI engineering and silicon concepts that is tailored for the student of digital design. It is introduced as the bottom of the design hierarchy and emphasizes the main ideas in physical design and VLSI that are important to large systems engineering. Both chapters have been written to be accessible to all students in electrical engineering, computer engineering, and computer science. They provide a real-world perspective that is often missing from more standard treatments.

Chapter 8, *Logic Components,* is directed toward examining useful network functions that are created using primitive gates. The list of components includes, among others, decoders, multiplexors, and adders. These are introduced as motivation for moving upward in the system hierarchy. **Chapter 9,** *Memory Elements and Arrays,* introduces the concepts of storage via latches, flip-flops, RAM, and ROM. The material in Section 9.9 is an introduction to the operation of CD-ROMs as a real-world example that illustrates many advanced concepts. **Chapter 10** introduces *Sequential Logic Networks.*

Computer fundamentals are covered in the last two chapters of the book in a manner that teaches the basics while simultaneously reinforcing the ideas of system hierarchies. **Chapter 11,** *Computer Basics,* covers the operations that define a computer, then continues on to discuss the primary components and simple architectural concepts. This treatment is quite general, but is designed to provide a solid understanding of the principles. **Chapter 12,** *Advanced Computer Concepts,* covers topics that are important in modern microcomputers, such as pipelining, cache memory, and superscalar designs. It ends with an introduction to the primary concepts involved in parallel processing and ideas for the evolution of computing.

Level of the Treatment

Even though the book introduces some relatively unique aspects of the field to the beginner, every effort was made to keep the discussion at a uniform level. It should be accessible to any student in electrical engineering, computer engineering, and computer science who has completed the standard freshman curriculum.

The book was specifically written for a first course in the subject, and the material has been class-tested to ensure that the treatment is coherent. The goal was to provide enough details so that the student would have an understanding of both the qualitative and quantitative aspects of every topic. It was not, however, designed to provide advanced discussions and detailed analyses; complex issues should be covered in higher-level courses. This book can be used to establish the background for taking advanced courses in the subjects of digital design, computer architecture, VHDL, electronic circuits, and VLSI. The exception to this might be VHDL, as we find it useful to incorporate the subject into the same course using a separate text and computer tools. Alternatively, the book is sufficient by itself as an introduction to digital design for the non-specialist.

Use of the Text

It is possible to use the text in several ways that vary with the intended emphasis. The outline provides three distinct topical groups: logic design, integration and VLSI, and basic computer architecture.

The fundamentals of logic design are covered in Chapters 1, 2, 3, 8, 9, and 10. These can be used as the basis for such a course by omitting some sections in the later chapters that deal with CMOS and VLSI. Including Chapter 5 on VHDL is highly recommended; in fact, if time permits, it would be worthwhile to expand the treatment in labs employing a specialized text. Chapter 4 deals with the real-world aspects of hardware delays, and the instructor should consider Sections 4.1 through 4.3 as a minimum introduction.

The details of hardware are contained in Chapters 4, 6, and 7. Each chapter has been written to present the most important concepts in the early sections. This allows the instructor to present some of the material without having to cover entire chapters. In Chapter 6, Sections 6.1 through 6.5 provide the basics, while the remaining sections take the reader to a more advanced level. The material in Chapter 7 through Section 7.4.1 gives the reader an overview of silicon integrated circuits. Section 7.6 (*Cells, Libraries, and Hierarchical Design*) is worth consideration as it emphasizes some important points about the design process. The other sections in the chapter are optional but enhance the overall theme. These chapters have been used independently as a VLSI primer for senior and graduate students and working engineers.

Chapters 11 and 12 are an introduction to computers and computer architectures. They discuss the fundamentals of what a computer is and how it is built and set the foundation for more advanced studies. However, they are sufficiently detailed to ensure that the students have seen the important concepts even if they do not take another course in the subject.

This book was written with the student in mind. In less than 500 pages it presents many fields that are traditionally taught only in advanced courses, where the student often is left with the task of linking diverse material and concepts. There is an emphasis on design hierarchies throughout the text. Using this view as a central theme, the book introduces design process at all levels, from the bottom-up and from the top-down.

It is important to restate that this book is intended for use in a **first course** on digital systems. Students who are specializing in any (or all) of the areas need to take more advanced courses to achieve the level expected of a graduating engineer or computer scientist. Every topic could have been taken to a much higher level but that would have defeated the main purpose. There are many fine textbooks that are more advanced and can be used in a follow-up course for specialists. The lower level material in an advanced book can be be treated as review or ignored completely. This allows the instructor to place emphasis on the more difficult and time-consuming presentations. Topics such as advanced sequential circuits, VHDL, CMOS VLSI systems, and computer architecture fall into this category. A solutions manual for the exercises is available to the instructor.

Philosophy

This book covers the material that I feel every student in electrical engineering, computer engineering, and computer science should know before graduating.

As a teacher, I often worry that our program delegates many important topics to elective courses. And for an engineer facing the challenges of the new century, understanding basic concepts in digital networks and computers ranks among the most critical. Not that every one needs to know how to design a high-performance computer, just how the system is put together and how it works. I tell my "non-digital" students (in fields such as circuit design, electromagnetics, and fiber optics) that I think they should be able to read and understand technical articles at the "popular" level—such as those found in *Byte* magazine. If they can accomplish a task at this level, then I am more at ease with the job we are doing as educators.

The decade of the 1990s has proved to be one of remarkable technological advances. The "computer revolution" has affected every aspect of society. Problems that were once thought intractable can now be solved and our imaginations run rampant with new possibilities. Few would disagree with these observations. Yet our approach to teaching the fundamentals of digital logic remain almost the same as that which was used 25 years ago when I first learned the material. By "approach" I mean to say that digital logic has generally been taught as a stand-alone fundamental course with only a small amount of hardware and system design. Students who want to go deeper into related subjects must take additional courses. While this works fine in principle, it ignores the fact that the subject is no longer practiced as a stand-alone art. Modern digital design relies on engineering groups made up of individuals that have an understanding of all aspects of the problem, from the top to the bottom in the hierarchical chain, with expertise in one or two areas.

A recent example illustrates this point. Several interviewers from a major integrated circuit company contacted me to discuss their "ideal" engineering candidate. They said that the great majority of the students they interviewed wanted to be involved in microprocessor design, but only about 25% of them had any background in VLSI. They were not necessarily looking for circuit designers, but felt that it should be obvious to every potential employee that microprocessors are made in silicon, and that even the system architects and tool designers needed to know some of the basics of VLSI. Although this is admittedly a specialized case, the applications of digital VLSI devices such as ASICs and FPGAs have expanded at a furious pace. If we as educators do not provide the background for future growth, then our graduates risk becoming obsolete very quickly.

With this book, I put forth the view that modern digital logic consists of several interacting areas that combine in a cohesive fashion. This includes traditional topics such as Boolean algebra, logic formalisms, Karnaugh maps, and most of the subjects one would expect to find. But it goes well beyond these traditional subject areas by including VHDL, CMOS, VLSI and RISC computer architectures to show what the field looks like to a modern logic designer.

There is a deeper motivation for writing a book of this type. The integration of diverse topics into a single course addresses some of the new curriculum issues that are beginning to tear away at existing programs. At Georgia Tech, we have been immersed in redesigning the electrical engineering/computer engineering curriculum to address the needs of the next generation. Overall, we have concluded that we must change our current educational paradigms to accomplish this goal. However, we are still working on the details. This book is one idea for the change. It provides the fundamentals of *modern* digital systems design while still working within *classical* boundaries. The difference is that many so-called "advanced" topics have migrated to the introductory level. But this is normal evolution. One does not need a good memory to recall when computer architecture was exclusively a graduate level course.

Digital systems design has expanded well beyond what can be covered within the classical paradigms. But it is not alone. Virtually every field that traditionally forms the foundation of electrical and computer engineering has changed markedly during the past decade. It seems obvious that our approach to education in these areas needs to evolve in a similar manner. I thus offer this book as my contribution to the effort.

Acknowledgments

I would like to extend my appreciation to Suzanne Jeans, product development editor at Brooks/Cole, for her help during all phases of the project. Kelsey McGee, the production editor for the book, has been a pleasure to work with. Her diligence and keen eye, coupled with a wonderful personality and sense of humor, made a long and tedious task enjoyable! I cannot imagine having anyone finer for the job! Roy Neuhaus did a spectacular job creating the cover design (wouldn't you agree?) and deserves a hearty "well done!"

Many thanks to the reviewers who read through the various drafts of the book and were able to see the big picture as discussed in the preface: Donald W. Bouldin, University of Tennessee/Knoxville; Tri Caohuu, San Jose State University; Krishnendu Chakrabarty, Duke University; M. U. Farooq, West Virginia University Institute of Technology; Kenneth J. Hintz, George Mason University; Ben M. Huey, Arizona State University; Martin Kaliski, California Polytechnic State University; Ramakrishna Nunna, Stevens Institute of Technology; Samuel H. Russ, Mississippi State University; Kewal J. Saluja, University of Wisconsin/Madison; Richard R. Schultz, University of North Dakota; William G. Sutton, George Mason University; Val G. Tareski, North Dakota State University/Fargo; and Peter J. Warter, University of Delaware. It would have been easy to dismiss the approach as being too radical or far-afield, but they instead provided pages and pages of helpful comments, corrections, and suggestions that have greatly improved the contents and flow. Finding such a large group of highly qualified people with open minds was especially refreshing.

My wife Melba and my daughters, Christine and Valerie, are at the center of my life, and have always supported my writing projects. Were it not for them, a book such as this never would have found its way to the printer. So, I thank them once again for their endless love.

John P. Uyemura
Atlanta, Georgia

This book is dedicated to my wife

Melba Valerie

for her never-ending love and support
during our many years together.

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