Digital Logic Design Principles

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Preface

THE BOOK

This in an introductory-level book on the *principles* of digital logic design. It is intended for use by first- or second-year students of electrical engineering, computer engineering, or computer science. No previous knowledge of electrical circuits or of electronics is assumed. Others who need a first exposure to, or a refresher on, digital design principles may also find it useful.

Pedagogical Issues

The deductive process—applying general principles to specific cases—is usually well illustrated in textbooks. Often, on the authority of the author, a general concept or an approach to a topic, or some result, is stated, followed by examples of how to apply the concept. As students begin a topic, it is unclear to them what the motivation is for introducing a particular definition or general procedure. Students don't have a clear idea why this particular topic may be useful or interesting, or why and how anybody thought it up in the first place.

In this book, we include an inductive approach in the development of subject matter. This approach involves the development of a generally valid result from an examination of specific cases, the way a research investigation proceeds. An investigator reaches a generally valid result by carrying out a number of specific experiments or calculations. Sometimes the study of one or more specific cases leads to a conjecture about something generally valid. The conjecture is then explored and justified using previously established results.

In a similar vein, we introduce most topics in an exploratory spirit, rather than dropping them on the reader without any preceding justification. The tenor of the text is that we are conducting an investigative exploration, almost like a research project, for the purpose of discovering and assimilating knowledge about the subject under study. When a topic is introduced, a considerable effort is made to help students understand why we ought to devote time to it. After a particular topic has been exhausted (that is, when we are faced with the need for taking a further step) alternatives are explored. "We could do this or we could do that," the commentary might go; "let's first try this, for the following reasons." *Why* to pursue a particular thread and *how* a particular procedure might come about are just as important to clarify for the learner as the details of following that specific procedure or of applying some particular algorithm.

When a subject such as digital circuits reaches a degree of maturity, there is a tendency for a textbook to accquire some of the characteristics of an encyclopedia: every conceivable topic is "covered." This approach robs the learner of all the joys of discovery. The learner is given the complete story and told to learn it, mainly by practicing on exercises and problems like those that the book has just worked out. In this book, we try to avoid the pitfall of cataloguing for students all that we know on a subject. In the form of problems, we leave for students the pleasure of developing (with guidance) some results that are not essential for going on with the subject matter being developed, and so need not be part of the exposition.

Students learn best if they are engaged. There isn't much that authors can do to keep them engaged, but we do remind them to participate in the derivation of an equation by carrying out the missing steps, to observe the relevant features of a diagram or table by describing it carefully to themselves, or to think through a proposed plan before carrying it out in detail. We do this often.

Level of Presentation

The presentation of material in this book is at the introductory level, first or second year of college. However, the level of a book should not dictate the degree of rigor in the presentation. Everything treated in this book is treated with rigor.

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Topic Selection

There is nothing unusual in the selection of subject matter. The selection and ordering of topics has been carried out to facilitate use of the book at institutions with different calendars and a variety of emphases. The book can be used in courses spanning an academic year, either two semesters or three quarters, especially if attention is given to the laboratory component. (See the description of the laboratory manual in what follows.) By proper selection of chapters and topics within chapters, a one-semester course can also be accommodated. Several "enrichment" topics are introduced in sections that instructors can omit without incurring a subsequent penalty. Later sections or problems based on this material can be similarly omitted. The inclusion of such material permits students having more time or interest to benefit without penalizing others.

The choice of ABEL to introduce hardware description language (HDL) as a tool for design minimizes the effort of students to learn the language, thus enabling them to concentrate on the concepts behind designing with an HDL. All concepts of HDL specification, simulation, and synthesis can be taught using ABEL, and the student is not burdened with the task of learning the syntax and semantics of a complex language such as VHDL or Verilog.

Numbering Scheme for Equations and Figures

Some schemes for numbering sections, equations, and figures, and the manner of referring to them, can cause students to be distracted as they engage unproductively in reading the numbers and searching for them. In this book a sequential numbering system, starting fresh in each chapter, is used for both equations and figures. (On the few occasions when reference might be made to an equation in an earlier chapter, the chapter number is also given.) Similarly, major sections within a chapter are numbered consecutively, without a chapter identifier, but subsections and sub-subsections are not numbered, thus obviating the unproductive reading of such section numbers as 4.3-5 that might identify subsection 5 of section 3 in Chapter 4. Subsequent reference to such a particular subsection is rarely, if ever made in *any* book; hence, there is no reference value to such a numbering scheme. Not all equations, only significant ones or those to which reference might be made later, are numbered. When referring to an equation or figure, we spell out the name: "Equation" or "Figure."

Illustrations, Examples, Exercises, and Problems

When a particular topic is being developed, illustrations are used to illuminate it. Indeed, an illustration might precede the development of the topic as part of the process of induction. *Illustrations* are thus incorporated into the development of the material. There are also numbered *examples*, separated from the text and easily distinguished, which are worked out using the concepts just developed, together with other recently assimilated ideas.

Scattered throughout the development, but in a format that distinguishes them from the text, are numbered *exercises* for students to work out at the time they are studying the relevant sections. The purpose of these exercises is to provide reinforcement for the concepts under study by having students carry out some simple calculations and apply results then under discussion. They form part of the "research project" idea. The excitation requirements for one type of flip-flop might be developed within the text, for example; the excitation requirements for other types of flip-flops are then left as an exercise for the students to work out. Where useful, answers are provided so that students can confirm the results of their efforts. (Most of the time, especially if answers are brief and thus easy for students to glance at within the text, they are provided as footnotes.) The exercises do not simply call for repeating the steps of a just-worked-out example using changed values or circuit configurations. Hence, there is no need to provide worked-out examples before asking students to perform an exercise.

At the end of each chapter is a set of *problems*. The problems in each set range from a simple application of procedures developed in the book to a challenging solution of a more complex problem. Sometimes a problem requires students to apply a specified technique. At other times they are asked to solve a problem using two or more specified approaches and to compare the ease or difficulty. In both cases, they are practicing specific techniques and reinforcing their understanding of them. Sometimes the problem is open-ended so that students have to make decisions about the methods to use, and then apply them.

Text Supplements

There are two packages of supplements. One is provided to instructors who adopt the book for use in their courses and is not available to students. It includes a solutions manual that contains full solutions of all the problems in the book. It also includes a set of transparencies of appropriate figures from the book. The figures are enlarged so that instructors can use them in the classroom.

The other package consists of a laboratory manual. In the book itself, although specific families of digital circuits are referred to from time to time (e.g., 74LS02), major stress is on design *principles*. The laboratory manual is intended to engage students in the *practice* of digital design, using the latest in currently available tehnology. We show how specific design projects from the manual can be incorporated at specific points in the book. Even though some students may be learning about digital design from other texts, they too can use this laboratory manual to gain experience with digital design practice. For additional information concerning the laboratory manual, please review the text web site (http://www.wiley.com/college/elec/balabanian293512).

SOFTWARE

We recommend the use of schematic entry and timing and functional simulation in the laboratory from the beginning (even with simple experiments or labs). The Xilinx WebPack software can be used, and is available for free from the Xilinx web site (http://www.xilinx.com). This software supports the most recent version of ABEL, so students will be familiar with the user interface by the time Chapter 8 is reached.

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