DIGITAL ICs (A DESIGN PERSPECTIVE)
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to deal with the complexity issue. A design can be envisioned as a hierarchical composition of modules rather than a chaotic collection of transistors. At each design level, the complex, internal details of each of the composing modules are abstracted away and replaced by a *black box view,* or *model*. Examples of modeling levels are the transistor, gate, arithmetic operator, datapath, processor, and system levels. The impact of this *divide and conquer* approach is dramatic. Instead of having to deal with a myriad of elements, the designer considers only a handful of components, each characterized in performance and cost by a small number of parameters.

This design methodology, combined with an ever-increasing level of automation, suggests that the breed of digital circuit designers is soon to become extinct. This impression is reflected in the *VLSI design* instructional approach that addresses design in a **top-down** fashion, hiding the complex behavior of semiconductor devices.

Nothing is less true. While the top-down approach might work for a large number of circuits, the abstraction model suffers from major pitfalls and works only to a certain degree. In a high-performance circuit, for instance, the connection of one module to another influences the performance of both. The *interconnect wire* and associated parasitics become dominant factors in the circuit performance. The increasing *power dissipation* of high performance design translates into reduced reliability and increased packaging cost. Ensuring that the circuit operates correctly under these *high clock frequencies* is another challenge that faces the designer of advanced digital circuits. To address any of these issues requires an in-depth understanding of the underlying electrical concepts and constructs. This textbook covers these crucial concepts in detail and provides insights into factors that have a profound impact on reliability and performance.

In the ***bottom-up*** design philosophy, advocated in traditional digital circuit textbooks, the behavioral and performance model of a digital component is built starting from the transistor with all its peculiarities. While this approach results in an in-depth understanding of the component operation, it fails to translate this knowledge into a compact and simple model that can percolate upwards to help construct more complex modules. The prime talent of a good digital designer is to know when simplification is appropriate and when it is not. Acquiring this skill requires design experimentation and expertise. By taking a design-experimental approach, this book provides the student and professional the kind of hands-on experience that helps build that expertise.

It is my belief that bringing both circuit and systems views on design together results in a profound understanding of the design of complex digital circuits, while preparing the designer for new challenges that might be waiting around the corner. Only time will tell how successful this undertaking was.

Other Features This Book Offers

It is worth summarizing some other unique features we deem essential to accomplish the aforementioned goal and that form the underpinning of this textbook.

- Design-oriented perspectives are advocated throughout. Design challenges and guidelines are highlighted. Techniques introduced in the text are illustrated with real designs and complete SPICE analysis.

- It is the only current textbook that shows how to use the latest techniques to design complex high-performance, or low-power circuits.
- It covers crucial real-world system design issues such as signal integrity, power dissipation, interconnect, packaging, timing, and synchronization.
- It not only covers MOS but also addresses other high-performance technologies such as bipolar, BiCMOS, GaAs, and superconducting.
- It provides unique coverage of the latest design methodologies and tools, with a discussion of how to use them from a designers' perspective.
- It offers perspectives on how digital circuit technology might evolve in the future.
- The book features outstanding illustrations and a usable design-oriented four-color insert.
- An extensive instructional package is available over the internet from the author's web site at U.C. Berkeley. It includes design software, transparency masters, design problems, actual layouts, and hardware and software laboratories.

How to Use This Book

The core of the text is intended for use in a **senior-level digital circuit design class**. Around this kernel, we have included chapters and sections covering the more advanced topics. In the course of developing this book, it became obvious quickly that it is hard to define a subset of the digital circuit design domain that covers everyone's needs. On the one hand, a newcomer to the field needs detailed coverage of the basic concepts. On the other hand, feedback from early readers and reviewers indicated that an in-depth and extensive coverage of advanced topics and current issues is desirable and necessary. Providing this complete vision resulted in a text that exceeds the scope of a single-semester class. The more advanced material can be used as the basis for a **graduate class**. The wide coverage and the inclusion of state-of-the-art topics also makes the text useful as a reference work for professional engineers.

The organization of the material is such that the chapters can be taught or read in a great many ways, as long as a number of precedence relations are adhered to. An overview of these interdependencies is pictured in the chart below. The core of the text consists of Chapters 3, 4, 6, and 11. Chapters 1 and 2 can be considered as introductory. Students with a prior introduction to semiconductors can traverse quickly through Chapter 2. We urge