DIGITAL ELECTRONICS
AND DESIGN WITH VHDL
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Dedicated to Claudia, Patricia, Bruno, and Ricardo, who are my north, my sun, and my soul.

To professors and students: This book resulted from years of hard work as a professor and designer in EE. My deepest wish is to have it help in making your own work a little easier, which shall indeed be the only real measure of its success.

“As the builders say, the larger stones do not lie well without the lesser.”
*Plato* (428–348 BC)
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Preface

The book carefully and diligently covers all three aspects related to the teaching of digital circuits: digital principles, digital electronics, and digital design. The starting point was the adoption of some fundamental premises, which led to a detailed and coherent sequence of contents. Such premises are summarized below.

Book Premises

- The text is divided into two parts, with the theory in Chapters 1–18 and the lab components in Chapters 19–25 plus Appendices A and B. These parts can be taught in parallel if it is a course with lectures and lab, or they can be used separately if it is a lecture-only or lab-only course.

- The book provides a clear and rigorous distinction between combinational circuits and sequential circuits. In the case of combinational circuits, further distinction between logic circuits and arithmetic circuits is provided. In the case of sequential circuits, further distinction between regular designs and state-machine-based designs is made.

- The book includes new, modern digital techniques, related, for example, to code types and data protection used in data storage and data transmission, with emphasis especially on Internet-based applications.

- The circuit analysis also includes transistor-level descriptions (not only gate-level), thus providing an introduction to VLSI design, indispensable in modern digital courses.

- A description of new, modern technologies employed in the fabrication of transistors (both bipolar and MOSFET) is provided. The fabrication of memory chips, including promising new approaches under investigation, is also presented.

- The book describes programmable logic devices, including a historical review and also details regarding state of the art CPLD/FPGA chips.

- Examples and exercises are named to ease the identification of the circuit/design under analysis.

- Not only are VHDL synthesis examples included in the experimental part, but it also includes a summary of the VHDL language, a chapter on simulation with VHDL testbenches, and also a chapter on simulation with SPICE.

- Finally, a large number of complete experimental examples are included, constructed in a rigorous, detailed fashion, including real-world applications, complete code (not only partial sketches), synthesis of all circuits onto CPLD/FPGA chips, simulation results, and general explanatory comments.

Book Contents

The book can be divided into two parts, with the theory (lectures) in Chapters 1–18 and experimentations (laboratory) in Chapters 19–25 plus Appendices A and B. Each of these parts can be further divided as follows.

- Part I Theory (Lectures)
  - Fundamentals: Chapters 1–5
  - Advanced fundamentals: Chapters 6–7
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- Technology: Chapters 8–10
- Circuit design: Chapters 11–15
- Additional technology: Chapters 16–18

- Part II Experiments (Laboratory)
  - VHDL summary: Chapter 19
  - VHDL synthesis: Chapters 20–23
  - VHDL simulation: Chapter 24 and Appendix A
  - SPICE simulation: Chapter 25 and Appendix B

The book contains 163 enumerated examples, 622 figures, and 545 exercises.

Audience

This book addresses the specific needs of undergraduate and graduate students in electrical engineering, computer engineering, and computer science.

Suggestions on How to Use the Book

The tables below present suggestions for the lecture and lab sections. If it is a lecture-only course, then any of the three compositions in the first table can be employed, depending on the desired course level. Likewise, if it is a lab-only course, then any of the three options suggested in the second table can be used. In the more general case (lectures plus lab), the two parts should be taught in parallel. In the tables an ‘x’ means full content, a slash ‘/’ indicates a partial (introductory sections only) content, and a blank means that the chapter should be skipped. These, however, are just suggestions based on the author’s own experience, so they should serve only as a general reference.

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