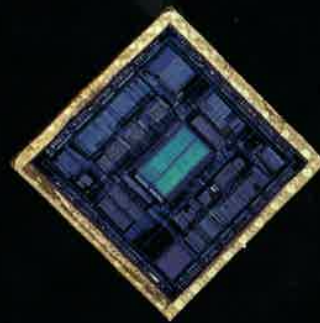


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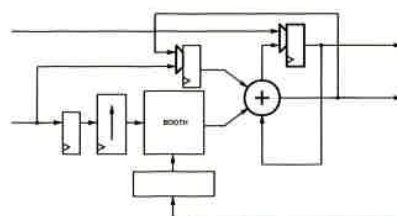
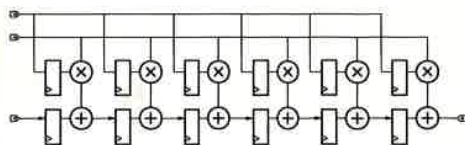
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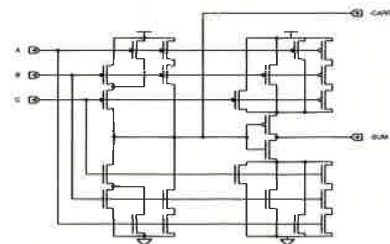
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A Systems Perspective

Second Edition

Neil H. E. Weste

TLW, Inc.

Kamran Eshraghian

University of Adelaide



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To Avril, Melissa, Tammy and Nicky
and Shohreh, Michelle, Kylie, Natasha and Jason

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PREFACE

In the eight years since this book was first published, CMOS technology has steadily moved to occupy a central position in modern electronic system design. Whether digital systems are high speed, high density, low power, or low cost, CMOS technology finds ubiquitous use in the majority of leading-edge commercial applications. CMOS processes have shrunk, and more automated design tools have become commonplace, leading to far more complex chips operating at much higher speeds than a decade ago. While the basic theory of CMOS design remains unchanged, the emphasis and approach to design have changed. With smaller processes and higher speeds comes an increased emphasis on clocking and power distribution, while with complex chip designs and short time-to-market constraints, less emphasis is now placed on die size and the physical details of chip design. The requirement for higher-quality CMOS chips has also increased the need for good approaches to testing.

This edition was updated with these changes in mind. All chapters have undergone extensive revision, and a new chapter on testing replaces one on symbolic layout. Sections on emerging technologies such as BiCMOS, logic synthesis, and parallel scan testing have been added. The overall emphasis has been to include as much as possible of the engineering (and to some extent, the economic) side of CMOS-system design. The artwork has been completely redone and many new figures have been added. All figures were captured on a CMOS VLSI design system. Thus, where possible, diagrams were checked via simulation or net comparison. The tendency has been to include figures where possible ("a picture is worth a thousand words") to trigger the reader's thinking.

As a text, this book provides students with the necessary background to complete CMOS designs and assess which particular design style to use on a given design, from Field Programmable Gate Arrays to full custom design. For the practicing designer, the book provides an extensive source of reference material that covers contemporary CMOS logic, circuit, design, and processing technology.

In common with the first edition, the text is divided into three main sections. The first deals with basic CMOS logic and circuit design and CMOS processing technology. This includes design issues such as speed, power dissipation, and clocking and subsystem design. The second section deals with design approaches and testing. The final section describes three examples of CMOS module/chip designs to provide working examples of the material presented in the first two parts of the book.

In the eighties, designers struggled with tools, circuit techniques, and technology to build CMOS digital systems that could frequently be mastered by one person. The design issues, for example, related to whether a simulation for a circuit could be done and, if so, how accurately. Or perhaps the success of a project depended on a router or a design-rule checker that could deal with large databases. Today, the technology has moved to a point where, to a first order, the technology always works. Failures in design relate to incomplete specifications, inadequate testing, poor communication between designers in a team, or other issues that are somewhat removed from the detailed engineering that still has to take place. That engineering is supported by well-developed design tools. A significant task to be mastered in today's world (once the basics have been learnt) is to take a specification, turn it into a design, enter the design into a CAD system, test it, have it manufactured, and then be able to ship the product.

Increasingly, CMOS VLSI design is being seen as an ideal medium in which to teach the general digital (and analog) system design principles required in such a design process by introducing such issues as structured design and testing. Coupled with education-based Field Programmable Logic Array tools and prototyping kits, courses can be crafted around the basic principles of CMOS design, such as logic design and delay estimation, and coupled with more advanced topics such as simulation, timing analysis, placement and routing, and testing. With reprogrammable hardware, the concept-to-reality delay is reduced to minutes, and the education dynamics of almost-real-time feedback can only help in the education of tomorrow's system designers. The principles used in these laboratory systems are then applicable, with suitable modifications and information, to real-world products, whether such products employ gate-array, standard-cell, or full-custom CMOS design techniques.

Burlington, Mass.

N. H. E. W.

Technical Note: The text was revised using Microsoft Word 4/5 on an Apple Mac II (8Mb RAM, 1.2Gb disk) from a scanned OCR'ed version of the first-edition text. The figures were captured by the author using the TLW NS VLSI design software (developed at Symbolics) with custom Lisp code for specialized EPS output and for capturing SPICE simulation results. The NS design system was run under the Genera operating system on the Mac II, using a Symbolics MacIvory 2 board (2.6 Mwords physical memory, 400Mb of paging space), and a Symbolics XL 1200 Lisp machine. All design work (symbolic layout and schematic capture, net comparison, SPICE, timing and switch simulation, compaction, and timing analysis) dealt with in the book was completed on these machines. In fact, an interesting example of "the wheel of reincarnation" applies: the first edition of the book was used in part to create the Ivory Lisp microprocessor, while the processor was used in turn to create the second edition of the text.

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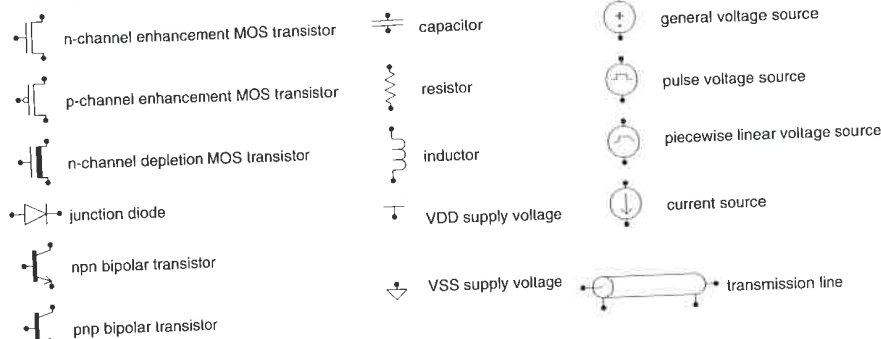
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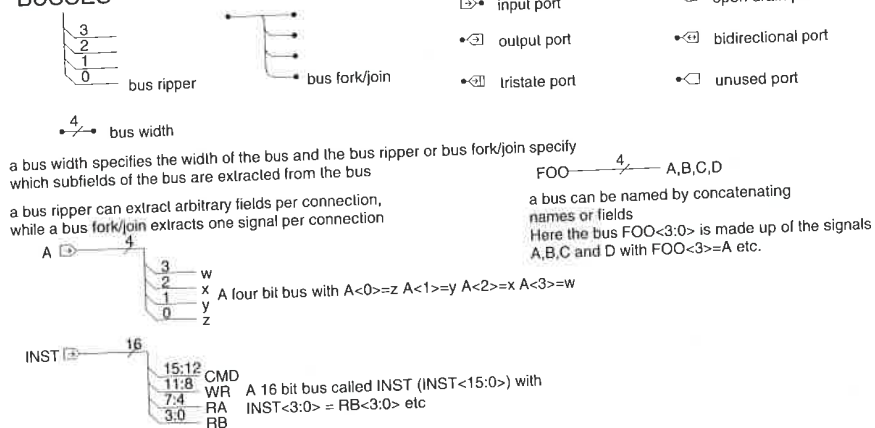
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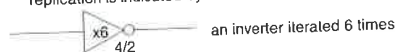


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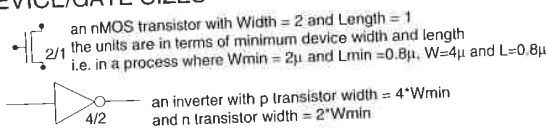


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DEVICE/GATE SIZES



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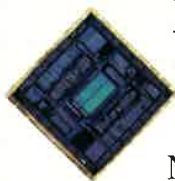
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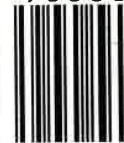
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