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VERILOG HDL, Second Edition by Samir Palnitkar With a Foreword by Prabhu Goel Written for both experienced and new users, this book gives you broad coverage of Verilog HDL. The book stresses the practical design and verification perspective of Verilog rather than emphasizing only the language aspects. The information presented is fully compliant with the IEEE 1364-2001 Verilog HDL standard. Among its many features, this edition:

- Describes state-of-the-art verification methodologies
- Provides full coverage of gate, dataflow (RTL), behavioral and switch modeling
- Introduces you to the Programming Language Interface (PLI)
- Describes logic synthesis methodologies
- Explains timing and delay simulation
- Discusses user-defined primitives
- Offers many practical modeling tips

Includes over 300 illustrations, examples, and exercises, and a Verilog resource list. Learning objectives and summaries are provided for each chapter. About the CD-ROM The CD-

ROM contains a Verilog simulator with a graphical user interface and the source code for the examples in the book. What people are saying about Verilog HDL: "Mr. Palnitkar illustrates how and why Verilog HDL is used to develop today's most complex digital designs. This book is valuable to both the novice and the experienced Verilog user. I highly recommend it to anyone exploring Verilog-based design." -Rajeev Madhavan, Chairman and CEO, Magma Design Automation "This book is unique in its breadth of information on Verilog and Verilog-related topics. It is fully compliant with the IEEE 1364-2001 standard, contains all the information that you need on the basics, and devotes several chapters to advanced topics such as verification, PLI, synthesis and modeling techniques." -Michael McNamara, Chair, IEEE 1364-2001 Verilog Standards Organization "This has been my favorite Verilog book since I picked it up in college. It is the only book that covers practical Verilog. A must have for beginners and experts." -Berend Ozceri, Design Engineer,

Cisco Systems, Inc. "Simple, logical and well-organized material with plenty of illustrations, makes this an ideal textbook." -Arun K. Somani, Jerry R. Junkins Chair Professor, Department of Electrical and Computer Engineering, Iowa State University, Ames PRENTICE HALL Professional Technical Reference Upper Saddle River, NJ 07458 www.phptr.com ISBN: 0-13-044911-3

Offers comprehensive coverage of digital CMOS circuit design, as well as addressing technology issues highlighted by the widespread use of nanometer-scale CMOS technologies.

In some places, the order of presentation has been changed to fine-tune the book's effectiveness as a senior and graduate-level teaching text. Fabrication principles covered include those for such circuits as CMOS, BIPOLAR, BICMOS, FET, and more.

The book discusses the latest developments and outlines future trends in the fields of microelectronics, electromagnetics and telecommunication. It contains original research works presented at the International Conference on Microelectronics, Electromagnetics and Telecommunication (ICMEET 2018), organised by GVP College of Engineering (A), Andhra Pradesh, India. The respective papers were written by scientists, research scholars and practitioners from leading universities, engineering colleges and R&D institutes from all over the world, and share the latest breakthroughs in and promising solutions to the most important issues facing today's society.

In this book, a variety of topics related to Very-Large-Scale Integration (VLSI) is extensively discussed. The topics encompass the physics of VLSI transistors, the process of integrated chip design and fabrication and the applications of VLSI

devices. It is intended to provide information on the latest advancement of VLSI technology to researchers, physicists as well as engineers working in the field of semiconductor manufacturing and VLSI design.

Practical Low Power Digital VLSI Design emphasizes the optimization and trade-off techniques that involve power dissipation, in the hope that the readers are better prepared the next time they are presented with a low power design problem. The book highlights the basic principles, methodologies and techniques that are common to most CMOS digital designs. The advantages and disadvantages of a particular low power technique are discussed. Besides the classical area-performance trade-off, the impact to design cycle time, complexity, risk, testability and reusability are discussed. The wide impacts to all aspects of design are what make low power problems challenging and interesting. Heavy emphasis is given to top-down structured design style, with occasional coverage in the semicustom design methodology. The examples and design techniques cited have been known to be applied to production scale designs or laboratory settings. The goal of Practical Low Power Digital VLSI Design is to permit the readers to practice the low power techniques using current generation design style and process technology. Practical Low Power Digital VLSI Design considers a wide range of design abstraction levels spanning circuit, logic, architecture and system. Substantial basic knowledge is provided for qualitative and quantitative analysis at the different design abstraction levels. Low power techniques are presented at the circuit, logic, architecture and system levels. Special techniques that are specific to some key areas of digital chip design are discussed as well as some of the low

power techniques that are just appearing on the horizon. Practical Low Power Digital VLSI Design will be of benefit to VLSI design engineers and students who have a fundamental knowledge of CMOS digital design.

System-on-a-chip (SoC) designs result in a wide range of high-complexity, high-value semiconductor products. As the technology scales towards smaller feature sizes and chips grow larger, a speed limitation arises due to an increased RC delay associated with interconnection wires. Innovative circuit techniques are required to achieve the speed needed for high-performance signal processing. Current sensing is considered as a promising circuit class since it is inherently faster than conventional voltage sense amplifiers. However, especially in SRAM, current sensing has rarely been used so far. Practical implementations are challenging because they require sophisticated analog circuit techniques in a digital environment. The objective of this book is to provide a systematic and comprehensive insight into current sensing techniques. Both theoretical and practical aspects are covered. Design guidelines are derived by systematic analysis of different circuit principles. Innovative concepts like compensation of the bit line multiplexer and auto-power-down will be explained based on theory and experimental results. The material will be interesting for design engineers in industry as well as researchers who want to learn about and apply current sensing techniques. The focus is on embedded SRAM but the material presented can be adapted to single-chip SRAM and to any other current-providing memory type as well. This includes emerging memory technologies like magnetic RAM (MRAM) and Ovonic Unified Memory (OUM). Moreover, it is also applicable to array like

structures such as CMOS camera chips and to circuits for signal transmission along highly capacitive busses.

Regular Fabrics in Deep Sub-Micron Integrated-Circuit Design discusses new approaches to better timing-closure and manufacturability of DSM Integrated Circuits. The key idea presented is the use of regular circuit and interconnect structures such that area/delay can be predicted with high accuracy. The co-design of structures and algorithms allows great opportunities for achieving better final results, thus closing the gap between IC and CAD designers. The regularities also provide simpler and possibly better manufacturability. In this book we present not only algorithms for solving particular sub-problems but also systematic ways of organizing different algorithms in a flow to solve the design problem as a whole. A timing-driven chip design flow is developed based on the new structures and their design algorithms, which produces faster chips in a shorter time.

Physical Design for Multichip Modules collects together a large body of important research work that has been conducted in recent years in the area of Multichip Module (MCM) design. The material consists of a survey of published results as well as original work by the authors. All major aspects of MCM physical design are discussed, including interconnect analysis and modeling, system partitioning and placement, and multilayer routing. For readers unfamiliar with MCMs, this book presents an overview of the different MCM technologies available today. An in-depth discussion of various recent approaches to interconnect analysis are also presented. Remaining chapters discuss the problems of partitioning, placement, and multilayer routing, with an emphasis on timing performance. For

the first time, data from a wide range of sources is integrated to present a clear picture of a new, challenging and very important research area. For students and researchers looking for interesting research topics, open problems and suggestions for further research are clearly stated. Points of interest include : Clear overview of MCM technology and its relationship to physical design; Emphasis on performance-driven design, with a chapter devoted to recent techniques for rapid performance analysis and modeling of MCM interconnects; Different approaches to multilayer MCM routing collected together and compared for the first time; Explanation of algorithms is not overly mathematical, yet is detailed enough to give readers a clear understanding of the approach; Quantitative data provided wherever possible for comparison of different approaches; A comprehensive list of references to recent literature on MCMs provided.

The fourth edition of CMOS Digital Integrated Circuits: Analysis and Design continues the well-established tradition of the earlier editions by offering the most comprehensive coverage of digital CMOS circuit design, as well as addressing state-of-the-art technology issues highlighted by the widespread use of nanometer-scale CMOS technologies. In this latest edition, virtually all chapters have been re-written, the transistor model equations and device parameters have been revised to reflect the significant changes that must be taken into account for new technology generations, and the material has been reinforced with up-to-date examples. The broad-ranging coverage of this textbook starts with the fundamentals of CMOS process technology, and continues with MOS transistor models, basic CMOS gates, interconnect effects, dynamic circuits, memo-

ry circuits, arithmetic building blocks, clock and I/O circuits, low power design techniques, design for manufacturability and design for testability.

This book teaches the principles of physical design, layout, and simulation of CMOS integrated circuits. It is written around a very powerful CAD program called Microwind that is available on the accompanying CD-ROM. Featuring a friendly interface, Microwind is both educational and useful for designing CMOS chips.

CMOS Digital Integrated Circuits: Analysis and Design is the most complete book on the market for CMOS circuits. Appropriate for electrical engineering and computer science, this book starts with CMOS processing, and then covers MOS transistor models, basic CMOS gates, interconnect effects, dynamic circuits, memory circuits, BiCMOS circuits, I/O circuits, VLSI design methodologies, low-power design techniques, design for manufacturability and design for testability. This book provides rigorous treatment of basic design concepts with detailed examples. It typically addresses both the computer-aided analysis issues and the design issues for most of the circuit examples. Numerous SPICE simulation results are also provided for illustration of basic concepts. Through rigorous analysis of CMOS circuits in this text, students will be able to learn the fundamentals of CMOS VLSI design, which is the driving force behind the development of advanced computer hardware.

The second edition of VLSI Design is a comprehensive textbook designed for undergraduate students of electrical, electronics, and electronics and communication engineering. It provides a thorough understanding of the fundamental concepts and design of VLSI systems.

Using the book and the software provided with it, the reader can build his/her own tester arrangement to investigate key aspects of analog-, digital- and mixed system circuits. Plan of attack based on traditional testing, circuit design and circuit manufacture allows the reader to appreciate a testing regime from the point of view of all the participating interests. Worked examples based on theoretical bookwork, practical experimentation and simulation exercises teach the reader how to test circuits thoroughly and effectively.

CD-ROM contains: AIM SPICE (from AIM Software) -- Micro-Cap 6 (from Spectrum Software) -- Silos III Verilog Simulator (from Simucad) -- Adobe Acrobat Reader 4.0 (from Adobe).

As the complexity and the density of VLSI chips increase with shrinking design rules, the evaluation of long-term reliability of MOS VLSI circuits is becoming an important problem. The assessment and improvement of reliability on the circuit level should be based on both the failure mode analysis and the basic understanding of the physical failure mechanisms observed in integrated circuits. Hot-carrier induced degradation of MOS transistor characteristics is one of the primary mechanisms affecting the long-term reliability of MOS VLSI circuits. It is likely to become even more important in future generation chips, since the downward scaling of transistor dimensions without proportional scaling of the operating voltage aggravates this problem. A thorough understanding of the physical mechanisms leading to hot-carrier related degradation of MOS transistors is a prerequisite for accurate circuit reliability evaluation. It is also being recognized that important reliability concerns other than the post-manufacture reliability qualification need to be addressed rigor-

ously early in the design phase. The development and use of accurate reliability simulation tools are therefore crucial for early assessment and improvement of circuit reliability. Once the long-term reliability of the circuit is estimated through simulation, the results can be compared with predetermined reliability specifications or limits. If the predicted reliability does not satisfy the requirements, appropriate design modifications may be carried out to improve the resistance of the devices to degradation.

Silicon-On-Insulator (SOI) CMOS technology has been regarded as another major technology for VLSI in addition to bulk CMOS technology. Owing to the buried oxide structure, SOI technology offers superior CMOS devices with higher speed, high density, and reduced second order effects for deep-submicron low-voltage, low-power VLSI circuits applications. In addition to VLSI applications, and because of its outstanding properties, SOI technology has been used to realize communication circuits, microwave devices, BICMOS devices, and even fiber optics applications. CMOS VLSI Engineering: Silicon-On-Insulator addresses three key factors in engineering SOI CMOS VLSI - processing technology, device modelling, and circuit designs are all covered with their mutual interactions. Starting from the SOI CMOS processing technology and the SOI CMOS digital and analog circuits, behaviors of the SOI CMOS devices are presented, followed by a CAD program, ST-SPICE, which incorporates models for deep-submicron fully-depleted mesa-isolated SOI CMOS devices and special purpose SOI devices including polysilicon TFTs. CMOS VLSI Engineering: Silicon-On-Insulator is written for undergraduate senior students and first-year graduate students interested in CMOS VLSI. It

will also be suitable for electrical engineering professionals interested in microelectronics.

This practical, tool-independent guide to designing digital circuits takes a unique, top-down approach, reflecting the nature of the design process in industry. Starting with architecture design, the book comprehensively explains the why and how of digital circuit design, using the physics designers need to know, and no more.

Contains the most extensive coverage of digital integrated circuits available in a single source. Provides complete qualitative descriptions of circuit operation followed by in-depth analytical analyses and spice simulations. The circuit families described in detail are transistor-transistor logic (TTL, STTL, and ASTTL), emitter-coupled logic (ECL), NMOS logic, CMOS logic, dynamic CMOS, BiCMOS structures and various GASFET technologies. In addition to detailed presentation of the basic inverter circuits for each digital logic family, complete details of other logic circuits for these families are presented.

This is an up-to-date treatment of the analysis and design of CMOS integrated digital logic circuits. The self-contained book covers all of the important digital circuit design styles found in modern CMOS chips, emphasizing solving design problems using the various logic styles available in CMOS.

This book constitutes the refereed proceedings of the International Conference on High Performance Architecture and Grid Computing, HPAGC 2011, held in Chandigarh, India, in July 2011. The 87 revised full papers presented were carefully reviewed and selected from 240 submissions. The papers are organized in topical sections on grid and cloud computing;

high performance architecture; information management and network security.

This book, first published in 2004, is an expanded and revised edition of Tom Lee's acclaimed RFIC text.

Beginning with discussions on the operation of electronic devices and analysis of the nucleus of digital design, the text addresses: the impact of interconnect, design for low power, issues in timing and clocking, design methodologies, and the effect of design automation on the digital design perspective.

In response to tremendous growth and new technologies in the semiconductor industry, this volume is organized into five, information-rich sections. Digital Design and Fabrication surveys the latest advances in computer architecture and design as well as the technologies used to manufacture and test them. Featuring contributions from leading experts, the book also includes a new section on memory and storage in addition to a new chapter on nonvolatile memory technologies. Developing advanced concepts, this sharply focused book— Describes new technologies that have become driving factors for the electronic industry Includes new information on semiconductor memory circuits, whose development best illustrates the phenomenal progress encountered by the fabrication and technology sector Contains a section dedicated to issues related to system power consumption Describes reliability and testability of computer systems Pinpoints trends and state-of-the-art advances in fabrication and CMOS technologies Describes performance evaluation measures, which are the bottom line from the user's point of view Discusses design techniques used to create modern computer systems, including high-speed computer arithmetic and high-frequency de-

sign, timing and clocking, and PLL and DLL design

CMOS, BiCMOS, and BiMOS.

The third edition of Hodges and Jackson's Analysis and Design of Digital Integrated Circuits has been thoroughly revised and updated by a new co-author, Resve Saleh of the University of British Columbia. The new edition combines the approachability and concise nature of the Hodges and Jackson classic with a complete overhaul to bring the book into the 21st century. The new edition has replaced the emphasis on BiPolar with an emphasis on CMOS. The outdated MOS transistor model used throughout the book will be replaced with the now standard deep submicron model. The material on memory has been expanded and updated. As well the book now includes more on SPICE simulation and new problems that reflect recent technologies. The emphasis of the book is on design, but it does not neglect analysis and has as a goal to provide enough information so that a student can carry out analysis as well as be able to design a circuit. This book provides an excellent and balanced introduction to digital circuit design for both students and professionals. While mobile phones enjoy the largest production volume ever of any consumer electronics products, the demands they place on radio-frequency (RF) transceivers are particularly aggressive, especially on integration with digital processors, low area, low power consumption, while being robust against process-voltage-temperature variations. Since mobile terminals inherently operate on batteries, their power budget is severely constrained. To keep up with the ever increasing data-rate, an ever-decreasing

power per bit is required to maintain the battery lifetime. The RF oscillator is the second most power-hungry block of a wireless radio (after power amplifiers). Consequently, any power reduction in an RF oscillator will greatly benefit the overall power efficiency of the cellular transceiver. Moreover, the RF oscillators' purity limits the transceiver performance. The oscillator's phase noise results in power leakage into adjacent channels in a transmit mode and reciprocal mixing in a receive mode. On the other hand, the multi-standard and multi-band transceivers that are now trending demand wide tuning range oscillators. However, broadening the oscillator's tuning range is usually at the expense of die area (cost) or phase noise. The main goal of this book is to bring forth the exciting and innovative RF oscillator structures that demonstrate better phase noise performance, lower cost, and higher power efficiency than currently achievable. Technical topics discussed in RF CMOS Oscillators for Modern Wireless Applications include: Design and analysis of low phase-noise class-F oscillators Analyze a technique to reduce $1/f$ noise up-conversion in the oscillators Design and analysis of low power/low voltage oscillators Wide tuning range oscillators Reliability study of RF oscillators in nanoscale CMOS

This textbook is ideal for senior undergraduate and graduate courses in RF CMOS circuits, RF circuit design, and high-frequency analog circuit design. It is aimed at electronics engineering students, as well as IC design engineers in the field, who wish to gain a deeper understanding of circuit fundamentals and go beyond the widely-used automated design procedures. A design-centric approach is adopted in order to bridge the gap between fundamental analog electronic cir-

cuits textbooks and more advanced RF IC design texts. The structure and operation of the building blocks of high-frequency ICs are introduced in a systematic manner, with an emphasis on transistor-level operation, the influence of device characteristics and parasitic effects, and input-output behavior in the time and frequency domains. This second edition has been revised extensively to expand and clarify some of the key topics and to provide a wide range of design examples and problems. New material has been added for basic coverage of core topics, such as wide-band LNAs, noise feedback concept and noise cancellation, inductive-compensated band widening techniques for flat-gain or flat-delay characteristics, and basic communication system concepts that exploit the convergence and co-existence of Analog and Digital building blocks in RF systems. A new chapter (Chapter 5) has been added on Noise and Linearity, addressing key topics in a comprehensive manner. All of the other chapters have also been revised and largely re-written, with the addition of numerous solved design examples and exercise problems. Designed for senior undergraduate and graduate courses in RF CMOS circuits, RF circuit design, and high-frequency analog circuit design; Uses simple circuit models to enable a robust understanding of high-frequency design fundamentals; Employs solved design examples to familiarize the reader with the design flow, starting with knowledge-based and model-based hand-design and progressing to SPICE simulations; Introduces fine-tuning procedures in circuit design with an emphasis on key trade-offs; Demonstrates key criteria and parameters that are used to describe system-level performance.

Low-Power Digital VLSI Design: Circuits and Systems addresses both process technologies and device modeling. Power dissipation in CMOS circuits, several practical circuit examples, and low-power techniques are discussed. Low-voltage issues for digital CMOS and BiCMOS circuits are emphasized. The book also provides an extensive study of advanced CMOS subsystem design. A low-power design methodology is presented with various power minimization techniques at the circuit, logic, architecture and algorithm levels. Features: Low-voltage CMOS device modeling, technology files, design rules Switching activity concept, low-power guidelines to engineering practice Pass-transistor logic families Power dissipation of I/O circuits Multi- and low-VT CMOS logic, static power reduction circuit techniques State of the art design of low-voltage BiCMOS and CMOS circuits Low-power techniques in CMOS SRAMS and DRAMS Low-power on-chip voltage down converter design Numerous advanced CMOS subsystems (e.g. adders, multipliers, data path, memories, regular structures, phase-locked loops) with several design options trading power, delay and area Low-power design methodology, power estimation techniques Power reduction techniques at the logic, architecture and algorithm levels More than 190 circuits explained at the transistor level.

A transistor-level, design-intensive overview of high speed and high frequency monolithic integrated circuits for wireless and broadband systems from 2 GHz to 200 GHz, this comprehensive text covers high-speed, RF, mm-wave, and optical fibre circuits using nanoscale CMOS, SiGe BiCMOS, and III-V technologies. Step-by-step design methodologies, end-of chapter problems, and practical simulation and design projects are provided,

making this an ideal resource for senior undergraduate and graduate courses in circuit design. With an emphasis on device-circuit topology interaction and optimization, it gives circuit designers and students alike an in-depth understanding of device structures and process limitations affecting circuit performance.

Exponential improvement in functionality and performance of digital integrated circuits has revolutionized the way we live and work. The continued scaling down of MOS transistors has broadened the scope of use for circuit technology to the point that texts on the topic are generally lacking after a few years. The second edition of *Digital Integrated Circuits: Analysis and Design* focuses on timeless principles with a modern interdisciplinary view that will serve integrated circuits engineers from all disciplines for years to come. Providing a revised instructional reference for engineers involved with Very Large Scale Integrated Circuit design and fabrication, this book delves into the dramatic advances in the field, including new applications and changes in the physics of operation made possible by relentless miniaturization. This book was conceived in the versatile spirit of the field to bridge a void that had existed between books on transistor electronics and those covering VLSI design and fabrication as a separate topic. Like the first edition, this volume is a crucial link for integrated circuit engineers and those studying the field, supplying the cross-disciplinary connections they require for guidance in more advanced work. For pedagogical reasons, the author uses SPICE level 1 computer simulation models but introduces BSIM models that are indispensable for VLSI design. This enables users to develop a strong and intuitive sense of device and circuit design by drawing direct connections be-

tween the hand analysis and the SPICE models. With four new chapters, more than 200 new illustrations, numerous worked examples, case studies, and support provided on a dynamic website, this text significantly expands concepts presented in the first edition.

Telecommunications is fundamental to modern society, with nearly everyone on the planet having access to a mobile phone, Wi-Fi, or satellite and terrestrial broadcast systems. This book is a concise analysis of both the basics of telecommunications as well as numerous advanced systems. It begins with a discussion of why we perform modulation of a carrier signal, continuing with a study of noise affecting all telecommunications links, be they digital or analogue in form. Digital communications techniques are examined in *Modern Telecommunications: Basic Principles and Practices*. Such an examination is crucial since radio, television, and satellite broadcasts are transmitted using a digital format. Analogue modulations are also considered. The logic behind such an investigation is because, whereas most broadcast systems are moving towards digital transmission, analogue techniques are still very much prevalent (most notably with AM and FM broadcasts). A topic that is often neglected in text books on telecommunications but is at the forefront of *Modern Telecommunications* concerns transmission lines. This is an important area of work since every length of coaxial cable used to convey signals from an antenna to a receiver is a transmission line. It is vitally important that a transmission line linking a transmitter to the antenna is matched and this topic is explored in great detail in several chapters dealing with Smith charts. Explains the background behind digital TV and radio as well as the legacy of ana-

logue transmissions. Presents materials in a way that minimizes mathematics, making the topic more approachable and interesting to users. Provides a look at familiar systems that readers encounter in their everyday life (including mobile phones, Wi-Fi hotspots, satellites, digital

TV, etc.). Demonstrates techniques and topics through end-of-chapter problems. Presents materials in an introductory form, making the information easily understandable and suitable for an undergraduate option course.