

***EE 671: VLSI DESIGN COURSE
for
Master and Bachelor Class of 2010***

Logical Effort- A Way of Designing Fast CMOS Circuits

Arun N. Chandorkar

Professor of Nano-Electronics and VLSI

Department of Electrical Engineering

Indian Institute of Technology Bombay.

Powai, Mumbai-400076, Maharashtra

E-Mail: anc@ee.iitb.ac.in

6th September 2010



Logical Effort Designing Fast Cmos Circuits

Jorge Juan Chico, Enrico Macii



Logical Effort Designing Fast Cmos Circuits:

Logical Effort Ivan Sutherland, Robert F. Sproull, David Harris, 1999 Designers of high speed integrated circuits face a bewildering array of choices and too often spend frustrating days tweaking gates to meet speed targets Logical Effort Designing Fast CMOS Circuits makes high speed design easier and more methodical providing a simple and broadly applicable method for estimating the delay resulting from factors such as topology capacitance and gate sizes The brainchild of circuit and computer graphics pioneers Ivan Sutherland and Bob Sproull logical effort will change the way you approach design challenges This book begins by equipping you with a sound understanding of the method s essential procedures and concepts so you can start using it immediately Later chapters explore the theory and finer points of the method and detail its specialized applications Features Explains the method and how to apply it in two practically focused chapters Improves circuit design intuition by teaching simple ways to discern the consequences of topology and gate size decisions Offers easy ways to choose the fastest circuit from among an array of potential circuit designs Reduces the time spent on tweaking and simulations so you can rapidly settle on a good design Offers in depth coverage of specialized areas of application for logical effort skewed or unbalanced gates other circuit families including pseudo NMOS and domino wide structures such as decoders and irregularly forking circuits Presents a complete derivation of the method so you see how and why it works

Low-Power CMOS Circuits Christian Pigué, 2018-10-03 The power consumption of microprocessors is one of the most important challenges of high performance chips and portable devices In chapters drawn from Pigué s recently published Low Power Electronics Design Low Power CMOS Circuits Technology Logic Design and CAD Tools addresses the design of low power circuitry in deep submicron technologies It provides a focused reference for specialists involved in designing low power circuitry from transistors to logic gates The book is organized into three broad sections for convenient access The first examines the history of low power electronics along with a look at emerging and possible future technologies It also considers other technologies such as nanotechnologies and optical chips that may be useful in designing integrated circuits The second part explains the techniques used to reduce power consumption at low levels These include clock gating leakage reduction interconnecting and communication on chips and adiabatic circuits The final section discusses various CAD tools for designing low power circuits This section includes three chapters that demonstrate the tools and low power design issues at three major companies that produce logic synthesizers Providing detailed examinations contributed by leading experts Low Power CMOS Circuits Technology Logic Design and CAD Tools supplies authoritative information on how to design and model for high performance with low power consumption in modern integrated circuits It is a must read for anyone designing modern computers or embedded systems

Design and Modeling of Low Power VLSI Systems Sharma, Manoj, Gautam, Ruchi, Khan, Mohammad Ayoub, 2016-06-06 Very Large Scale Integration VLSI Systems refer to the latest development in computer microchips which are created by integrating hundreds of thousands of transistors into one chip Emerging research

in this area has the potential to uncover further applications for VLSI technologies in addition to system advancements

Design and Modeling of Low Power VLSI Systems analyzes various traditional and modern low power techniques for integrated circuit design in addition to the limiting factors of existing techniques and methods for optimization Through a research based discussion of the technicalities involved in the VLSI hardware development process cycle this book is a useful resource for researchers engineers and graduate level students in computer science and engineering **Advances in Computer Science, Engineering & Applications** David C. Wyld, Jan Zizka, Dhinakaran Nagamalai, 2012-05-15 The International conference series on Computer Science Engineering Applications ICCSEA aims to bring together researchers and practitioners from academia and industry to focus on understanding computer science engineering and applications and to establish new collaborations in these areas The Second International Conference on Computer Science Engineering Applications ICCSEA 2012 held in Delhi India during May 25 27 2012 attracted many local and international delegates presenting a balanced mixture of intellect and research both from the East and from the West Upon a strenuous peer review process the best submissions were selected leading to an exciting rich and a high quality technical conference program which featured high impact presentations in the latest developments of various areas of computer science engineering and applications research **FPGA-Based System Design** Wayne Wolf, 2004-06-15 Everything FPGA designers need to know about FPGAs and VLSI Digital designs once built in custom silicon are increasingly implemented in field programmable gate arrays FPGAs Effective FPGA system design requires a strong understanding of VLSI issues and constraints and an understanding of the latest FPGA specific techniques In this book Princeton University's Wayne Wolf covers everything FPGA designers need to know about all these topics both the how and the why Wolf begins by introducing the essentials of VLSI fabrication circuits interconnects combinational and sequential logic design system architectures and more Next he demonstrates how to reflect this VLSI knowledge in a state of the art design methodology that leverages FPGA's most valuable characteristics while mitigating its limitations Coverage includes How VLSI characteristics affect FPGAs and FPGA based logic design How classical logic design techniques relate to FPGA based logic design Understanding FPGA fabrics the basic programmable structures of FPGAs Specifying and optimizing logic to address size speed and power consumption Verilog VHDL and software tools for optimizing logic and designs The structure of large digital systems including register transfer design methodology Building large scale platform and multi FPGA systems A start to finish DSP case study addressing a wide range of design problems PRENTICE HALL Professional Technical Reference Upper Saddle River NJ 07458 www.phptr.com ISBN 0 13 142461 0 **Cache and Memory Hierarchy Design** Steven A. Przybylski, 1990 A widely read and authoritative book for hardware and software designers This innovative book exposes the characteristics of performance optimal single and multi level cache hierarchies by approaching the cache design process through the novel perspective of minimizing execution time *Integrated Circuit and System Design. Power and Timing Modeling,*

Optimization and Simulation Jorge Juan Chico, Enrico Macii, 2003-10-02 Welcome to the proceedings of PATMOS 2003 This was the 13th in a series of international workshops held in several locations in Europe Over the years PATMOS has gained recognition as one of the major European events devoted to power and timing aspects of integrated circuit and system design Despite its significant growth and development PATMOS can still be considered as a very informal forum featuring high level scientific presentations together with open discussions and panel sessions in a free and relaxed environment This year PATMOS took place in Turin Italy organized by the Politecnico di Torino with technical co sponsorship from the IEEE Circuits and Systems Society and the generous support of the European Commission as well as that of several industrial sponsors including BullDAST Cadence Mentor Graphics STMicroelectronics and Synopsys The objective of the PATMOS workshop is to provide a forum to discuss and investigate the emerging problems in methodologies and tools for the design of new generations of integrated circuits and systems A major emphasis of the technical program is on speed and low power aspects with particular regard to modeling characterization design and architectures

Integrated Circuit Design. Power and Timing Modeling, Optimization and Simulation Bertrand Hochet, Antonio J. Acosta, Manuel J. Bellido, 2003-08-02 The International Workshop on Power and Timing Modeling Optimization and Simulation PATMOS 2002 was the 12th in a series of international workshops 1 previously held in several places in Europe PATMOS has over the years evolved into a well established and outstanding series of open European events on power and timing aspects of integrated circuit design The increased interest especially in low power design has added further momentum to the interest in this workshop Despite its growth the workshop can still be considered as a very useful conference featuring high level scientific presentations together with open discussions in a free and easy environment This year the workshop has been opened to both regular papers and poster presentations The increasing number of worldwide high quality submissions is a measure of the global interest of the international scientific community in the topics covered by PATMOS The objective of this workshop is to provide a forum to discuss and investigate the emerging problems in the design methodologies and CAD tools for the new generation of IC technologies A major emphasis of the technical program is on speed and low power aspects with particular regard to modeling characterization design and architectures The technical program of PATMOS 2002 included nine sessions dedicated to most important and current topics on power and timing modeling optimization and simulation The three invited talks try to give a global overview of the issues in low power and or high performance circuit design

Architecture Design and Validation Methods Egon Börger, 2012-12-06 This book grew out of material which was taught at the International Summer School on Architecture Design and Validation Methods held June 23 July 5 1997 on the Island of Lipari and directed to graduate students and young researchers Since then the course notes have been completely elaborated and extended and additional chapters have been added so that this book offers a comprehensive presentation of the state of the art which leads the reader to the forefront of the current research in the area The chapters each of which was written by a group of eminent

specialists in the field are self contained and can be read independently of each other They cover the wide range of theoretical and practical methods which currently used for the specification design validation and verification of are hardware software architectures Synthesis methods are the subject of the first three chapters The chapter on Modeling and Synthesis of Behavior Control and Data Flow focusses on techniques above the register transfer level The chapter on Cell Based Logic Optimizations concentrates on methods that interface logic design with physical design in particular on techniques for cell library binding the back end of logic synthesis The chapter on A Design Flow for Performance Planning presents new paradigms for iteration free synthesis where global wire plans for meeting timing constraints already appear at the conceptual design stage even before fixing the functionality of the blocks in the plan Integrated Circuit and System Design. Power and Timing Modeling, Optimization and Simulation Johan Vounckx, Nadine Azemard, 2006-09-08 This book constitutes the refereed proceedings of the 16th International Workshop on Power and Timing Modeling Optimization and Simulation PATMOS 2006 The book presents 41 revised full papers and 23 revised poster papers together with 4 key notes and 3 industrial abstracts Topical sections include high level design power estimation and modeling memory and register files low power digital circuits busses and interconnects low power techniques applications and SoC design modeling and more **Modern VLSI Design** Wayne Wolf, 2008-12-21 The Number 1 VLSI Design Guide Now Fully Updated for IP Based Design and the Newest Technologies Modern VLSI Design Fourth Edition offers authoritative up to the minute guidance for the entire VLSI design process from architecture and logic design through layout and packaging Wayne Wolf has systematically updated his award winning book for today's newest technologies and highest value design techniques Wolf introduces powerful new IP based design techniques at all three levels gates subsystems and architecture He presents deeper coverage of logic design fundamentals clocking and timing and much more No other VLSI guide presents as much up to date information for maximizing performance minimizing power utilization and achieving rapid design turnarounds

Circuits at the Nanoscale Krzysztof Iniewski, 2018-10-08 Circuits for Emerging Technologies Beyond CMOS New exciting opportunities are abounding in the field of body area networks wireless communications data networking and optical imaging In response to these developments top notch international experts in industry and academia present Circuits at the Nanoscale Communications Imaging and Sensing This volume unique in both its scope and its focus addresses the state of the art in integrated circuit design in the context of emerging systems A must for anyone serious about circuit design for future technologies this book discusses emerging materials that can take system performance beyond standard CMOS These include Silicon on Insulator SOI Silicon Germanium SiGe and Indium Phosphide InP Three dimensional CMOS integration and co integration with Microelectromechanical MEMS technology and radiation sensors are described as well Topics in the book are divided into comprehensive sections on emerging design techniques mixed signal CMOS circuits circuits for communications and circuits for imaging and sensing Dr Krzysztof Iniewski is a director at CMOS Emerging Technologies Inc

a consulting company in Vancouver British Columbia His current research interests are in VLSI circuits for medical applications He has published over 100 research papers in international journals and conferences and he holds 18 international patents granted in the United States Canada France Germany and Japan In this volume he has assembled the contributions of over 60 world reknown experts who are at the top of their field in the world of circuit design advancing the bank of knowledge for all who work in this exciting and burgeoning area

CMOS R. Jacob Baker, 2019-06-19 A revised guide to the theory and implementation of CMOS analog and digital IC design The fourth edition of CMOS Circuit Design Layout and Simulation is an updated guide to the practical design of both analog and digital integrated circuits The author a noted expert on the topic offers a contemporary review of a wide range of analog digital circuit blocks including phase locked loops delta sigma sensing circuits voltage current references op amps the design of data converters and switching power supplies CMOS includes discussions that detail the trade offs and considerations when designing at the transistor level The companion website contains numerous examples for many computer aided design CAD tools Using the website enables readers to recreate modify or simulate the design examples presented throughout the book In addition the author includes hundreds of end of chapter problems to enhance understanding of the content presented This newly revised edition Provides in depth coverage of both analog and digital transistor level design techniques Discusses the design of phase and delay locked loops mixed signal circuits data converters and circuit noise Explores real world process parameters design rules and layout examples Contains a new chapter on Power Electronics Written for students in electrical and computer engineering and professionals in the field the fourth edition of CMOS Circuit Design Layout and Simulation is a practical guide to understanding analog and digital transistor level design theory and techniques

Routing Congestion in VLSI Circuits Prashant Saxena, Rupesh S. Shelar, Sachin Sapatnekar, 2007-04-27 With dramatic increases in on chip packing densities routing congestion has become a major problem in integrated circuit design impacting convergence performance and yield and complicating the synthesis of critical interconnects The problem is especially acute as interconnects are becoming the performance bottleneck in modern integrated circuits Even with more than 30% of white space some of the design blocks in modern microprocessor and ASIC designs cannot be routed successfully Moreover this problem is likely to worsen considerably in the coming years due to design size and technology scaling There is an inherent tradeoff between choosing a minimum delay path for interconnect nets and the need to detour the routes to avoid traffic jams congestion management involves intelligent allocation of the available interconnect resources up front planning of the wire routes for even distributions and transformations that make the physical synthesis congestion aware The book explores this tradeoff that lies at the heart of all congestion management in seeking to address the key question how does one optimize the traditional design goals such as the delay or the area of a circuit while still ensuring that the circuit remains routable It begins by motivating the congestion problem explaining why this problem is important and how it will trend It then progresses with comprehensive

discussions of the techniques available for estimating and optimizing congestion at various stages in the design ow

Handbook of Algorithms for Physical Design Automation Charles J. Alpert,Dinesh P. Mehta,Sachin S.

Sapatnekar,2008-11-12 The physical design flow of any project depends upon the size of the design the technology the number of designers the clock frequency and the time to do the design As technology advances and design styles change physical design flows are constantly reinvented as traditional phases are removed and new ones are added to accommodate changes in technology Handbook of Algorithms for Physical Design Automation provides a detailed overview of VLSI physical design automation emphasizing state of the art techniques trends and improvements that have emerged during the previous decade After a brief introduction to the modern physical design problem basic algorithmic techniques and partitioning the book discusses significant advances in floorplanning representations and describes recent formulations of the floorplanning problem The text also addresses issues of placement net layout and optimization routing multiple signal nets manufacturability physical synthesis special nets and designing for specialized technologies It includes a personal perspective from Ralph Otten as he looks back on the major technical milestones in the history of physical design automation Although several books on this topic are currently available most are either too broad or out of date Alternatively proceedings and journal articles are valuable resources for researchers in this area but the material is widely dispersed in the literature This handbook pulls together a broad variety of perspectives on the most challenging problems in the field and focuses on emerging problems and research results

Integrated Circuit and System Design. Power and Timing Modeling, Optimization, and Simulation Rene van Leuken,Gilles Sicard,2011-02-04 This book constitutes the refereed proceedings of the 20th International Conference on Integrated Circuit and System Design PATMOS 2010 held in Grenoble France in September 2010 The 24 revised full papers presented and the 9 extended abstracts were carefully reviewed and are organized in topical sections on design flows circuit techniques low power circuits self timed circuits process variation high level modeling of poweraware heterogeneous designs in SystemC AMS and minalogic

Cartesian Genetic Programming Julian F. Miller,2011-09-18 Cartesian Genetic Programming CGP is a highly effective and increasingly popular form of genetic programming It represents programs in the form of directed graphs and a particular characteristic is that it has a highly redundant genotype phenotype mapping in that genes can be noncoding It has spawned a number of new forms each improving on the efficiency among them modular or embedded CGP and self modifying CGP It has been applied to many problems in both computer science and applied sciences This book contains chapters written by the leading figures in the development and application of CGP and it will be essential reading for researchers in genetic programming and for engineers and scientists solving applications using these techniques It will also be useful for advanced undergraduates and postgraduates seeking to understand and utilize a highly efficient form of genetic programming

Protecting Chips Against Hold Time Violations Due to Variability Gustavo Neuburger,Gilson Wirth,Ricardo Reis,2013-10-01 With the

development of Very Deep Sub Micron technologies process variability is becoming increasingly important and is a very important issue in the design of complex circuits Process variability is the statistical variation of process parameters meaning that these parameters do not have always the same value but become a random variable with a given mean value and standard deviation This effect can lead to several issues in digital circuit design The logical consequence of this parameter variation is that circuit characteristics as delay and power also become random variables Because of the delay variability not all circuits will now have the same performance but some will be faster and some slower However the slowest circuits may be so slow that they will not be appropriate for sale On the other hand the fastest circuits that could be sold for a higher price can be very leaky and also not very appropriate for sale A main consequence of power variability is that the power consumption of some circuits will be different than expected reducing reliability average life expectancy and warranty of products Sometimes the circuits will not work at all due to reasons associated with process variations At the end these effects result in lower yield and lower profitability To understand these effects it is necessary to study the consequences of variability in several aspects of circuit design like logic gates storage elements clock distribution and any other that can be affected by process variations The main focus of this book will be storage elements

Digital Computer Arithmetic Datapath Design Using Verilog HDL James E. Stine, 2012-12-06 The role of arithmetic in datapath design in VLSI design has been increasing in importance over the last several years due to the demand for processors that are smaller faster and dissipate less power Unfortunately this means that many of these datapaths will be complex both algorithmically and circuit wise As the complexity of the chips increases less importance will be placed on understanding how a particular arithmetic datapath design is implemented and more importance will be given to when a product will be placed on the market This is because many tools that are available today are automated to help the digital system designer maximize their efficiency Unfortunately this may lead to problems when implementing particular datapaths The design of high performance architectures is becoming more complicated because the level of integration that is capable for many of these chips is in the billions Many engineers rely heavily on software tools to optimize their work therefore as designs are getting more complex less understanding is going into a particular implementation because it can be generated automatically Although software tools are a highly valuable asset to designer the value of these tools does not diminish the importance of understanding datapath elements Therefore a digital system designer should be aware of how algorithms can be implemented for datapath elements Unfortunately due to the complexity of some of these algorithms it is sometimes difficult to understand how a particular algorithm is implemented without seeing the actual code

CMOS Processors and Memories Krzysztof Iniewski, 2010-08-09 CMOS Processors and Memories addresses the state of the art in integrated circuit design in the context of emerging computing systems New design opportunities in memories and processor are discussed Emerging materials that can take system performance beyond standard CMOS like carbon nanotubes graphene ferroelectrics and tunnel junctions are

explored CMOS Processors and Memories is divided into two parts processors and memories In the first part we start with high performance low power processor design followed by a chapter on multi core processing They both represent state of the art concepts in current computing industry The third chapter deals with asynchronous design that still carries lots of promise for future computing needs At the end we present a hardware design space exploration methodology for implementing and analyzing the hardware for the Bayesian inference framework This particular methodology involves analyzing the computational cost and exploring candidate hardware components proposing various custom architectures using both traditional CMOS and hybrid nanotechnology CMOL The first part concludes with hybrid CMOS Nano architectures The second memory part covers state of the art SRAM DRAM and flash memories as well as emerging device concepts Semiconductor memory is a good example of the full custom design that applies various analog and logic circuits to utilize the memory cell s device physics Critical physical effects that include tunneling hot electron injection charge trapping Flash memory are discussed in detail Emerging memories like FRAM PRAM and ReRAM that depend on magnetization electron spin alignment ferroelectric effect built in potential well quantum effects and thermal melting are also described CMOS Processors and Memories is a must for anyone serious about circuit design for future computing technologies The book is written by top notch international experts in industry and academia It can be used in graduate course curriculum

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