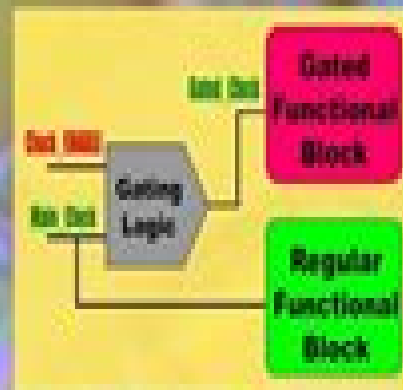
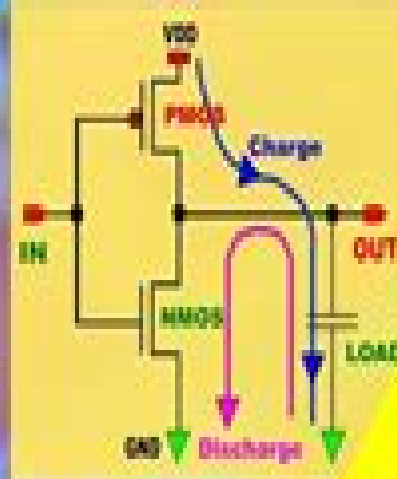


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# CMOS Low-Power Design In VLSI

# Low Power Cmos Design

**Vojin G. Oklobdzija**



## **Low Power Cmos Design:**

**Low Power Digital CMOS Design** Anantha P. Chandrakasan, Robert W. Brodersen, 1995-06-30 Power consumption has become a major design consideration for battery operated portable systems as well as high performance desktop systems. Strict limitations on power dissipation must be met by the designer while still meeting ever higher computational requirements. A comprehensive approach is thus required at all levels of system design ranging from algorithms and architectures to the logic styles and the underlying technology. Potentially one of the most important techniques involves combining architecture optimization with voltage scaling, allowing a trade off between silicon area and low power operation. Architectural optimization enables supply voltages of the order of 1 V using standard CMOS technology. Several techniques can also be used to minimize the switched capacitance including representation optimizing signal correlations minimizing spurious transitions optimizing sequencing of operations activity driven power down etc. The high efficiency of DC/DC converter circuitry required for efficient low voltage and low current level operation is described by Stratakis, Sullivan and Sanders. The application of various low power techniques to a chip set for multimedia applications shows that orders of magnitude reduction in power consumption is possible. The book also features an analysis by Professor Meindl of the fundamental limits of power consumption achievable at all levels of the design hierarchy. Svensson of ISI describes emerging adiabatic switching techniques that can break the CV<sup>2</sup>f barrier and reduce the energy per computation at a fixed voltage. Srivastava of AT&T presents the application of aggressive shut down techniques to microprocessor applications. **The Design and Implementation of Low-Power CMOS Radio Receivers** Derek Shaeffer, Thomas H. Lee, 2007-05-08 It is hardly a profound observation to note that we remain in the midst of a wireless revolution. In 1998 alone over 150 million cell phones were sold worldwide representing an astonishing 50% increase over the previous year. Maintaining such a remarkable growth rate requires constant innovation to decrease cost while increasing performance and functionality. Traditionally wireless products have depended on a mixture of semiconductor technologies spanning GaAs, bipolar and BiCMOS just to name a few. A question that has been hotly debated is whether CMOS could ever be suitable for RF applications. However given the acknowledged inferiority of CMOS transistors relative to those in other candidate technologies it has been argued by many that CMOS RF is an oxymoron, an endeavor best left cloistered in the ivory towers of academia. In rebuttal there are several compelling reasons to consider CMOS for wireless applications. Aside from the exponential device and density improvements delivered regularly by Moore's law only CMOS offers a technology path for integrating RF and digital elements potentially leading to exceptionally compact and low cost devices. To enable this achievement several thorny issues need to be resolved. Among these are the problem of poor passive components, broadband noise in MOSFETs and phase noise in oscillators made with CMOS. Beyond the component level there is also the important question of whether there are different architectural choices that one would make if CMOS were used given the different constraints. **Low-Power CMOS Design** Anantha

Chandrakasan, Robert W. Brodersen, 1998-02-11 This collection of important papers provides a comprehensive overview of low power system design from component technologies and circuits to architecture system design and CAD techniques LOW POWER CMOS DESIGN summarizes the key low power contributions through papers written by experts in this evolving field

**Low Power Design Methodologies** Jan M. Rabaey, Massoud Pedram, 2012-12-06 Low Power Design Methodologies presents the first in depth coverage of all the layers of the design hierarchy ranging from the technology circuit logic and architectural levels up to the system layer The book gives insight into the mechanisms of power dissipation in digital circuits and presents state of the art approaches to power reduction Finally it introduces a global view of low power design methodologies and how these are being captured in the latest design automation environments The individual chapters are written by the leading researchers in the area drawn from both industry and academia Extensive references are included at the end of each chapter Audience A broad introduction for anyone interested in low power design Can also be used as a text book for an advanced graduate class A starting point for any aspiring researcher Low-Power CMOS VLSI Circuit Design Kaushik Roy, Sharat Prasad, 2000-02-22 A comprehensive look at the rapidly growing field of low power VLSI design Low power VLSI circuit design is a dynamic research area driven by the growing reliance on battery powered portable computing and wireless communications products In addition it has become critical to the continued progress of high performance and reliable microelectronic systems This self contained volume clearly introduces each topic incorporates dozens of illustrations and concludes chapters with summaries and references VLSI circuit and CAD engineers as well as researchers in universities and industry will find ample information on tools and techniques for design and optimization of low power electronic systems Topics include Fundamentals of power dissipation in microelectronic devices Estimation of power dissipation due to switching short circuit subthreshold leakage and diode leakage currents Design and test of low voltage CMOS circuits Power conscious logic and high level synthesis Low power static RAM architecture Energy recovery techniques Software power estimation and optimization **Practical Low Power Digital VLSI Design** Gary K. Yeap, 2012-12-06 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.

**Design of Low-Voltage Low-Power CMOS Delta-Sigma A/D Converters** Vincenzo Peluso, Michiel Steyaert, Willy M.C. Sansen, 2013-03-09. Design of Low Voltage Low Power CMOS Delta Sigma A/D Converters investigates the feasibility of designing Delta Sigma Analog to Digital Converters for very low supply voltage lower than 1.5V and low power operation in standard CMOS processes. The chosen technique of implementation is the Switched Opamp Technique which provides Switched Capacitor operation at low supply voltage without the need to apply voltage multipliers or low  $V_t$  MOST devices. A method of implementing the classic single loop and cascaded Delta Sigma modulator topologies with half delay integrators is presented. Those topologies are studied in order to find the parameters that maximise the performance in terms of peak SNR. Based on a linear model the performance degradations of higher order single loop and cascaded modulators compared to a hypothetical ideal modulator are quantified. An overview of low voltage Switched Capacitor design techniques such as the use of voltage multipliers, low  $V_t$  MOST devices and the Switched Opamp Technique is given. An in depth discussion of the present status of the Switched Opamp Technique covers the single ended Original Switched Opamp Technique, the Modified Switched Opamp Technique which allows lower supply voltage operation and differential implementation including common mode control techniques. The restrictions imposed on the analog circuits by low supply voltage operation are investigated. Several low voltage circuit building blocks, some of which are new, are discussed. A new low voltage class AB OTA especially suited for differential Switched Opamp applications together with a common mode feedback amplifier and a comparator are presented and analyzed. As part of a systematic top down design approach the non ideal charge transfer of the Switched Opamp integrator cell is modeled based upon several models of the main opamp non ideal characteristics. Behavioral simulations carried out with these models yield the required opamp specifications that ensure that the intended performance is met in an implementation. A power consumption analysis is performed. The influence of all design parameters, especially the low power supply voltage, is highlighted. Design guidelines towards low power operation are distilled. Two implementations are presented together with measurement results. The first one is a single ended implementation of a Delta Sigma ADC operating with 1.5V supply voltage and consuming 100  $\mu$ W for a 74 dB dynamic range in a 3.4 kHz bandwidth. The second implementation is differential and operates with 900 mV. It achieves 77 dB dynamic range in 16 kHz bandwidth and consumes 40  $\mu$ W. Design of Low Voltage Low Power CMOS Delta Sigma A/D Converters is essential reading for analog design engineers and researchers.

**Low-Power Electronics Design** Christian

Piguet,2018-10-03 The power consumption of integrated circuits is one of the most problematic considerations affecting the design of high performance chips and portable devices The study of power saving design methodologies now must also include subjects such as systems on chips embedded software and the future of microelectronics Low Power Electronics Design covers all major aspects of low power design of ICs in deep submicron technologies and addresses emerging topics related to future design This volume explores in individual chapters written by expert authors the many low power techniques born during the past decade It also discusses the many different domains and disciplines that impact power consumption including processors complex circuits software CAD tools and energy sources and management The authors delve into what many specialists predict about the future by presenting techniques that are promising but are not yet reality They investigate nanotechnologies optical circuits ad hoc networks e textiles as well as human powered sources of energy Low Power Electronics Design delivers a complete picture of today s methods for reducing power and also illustrates the advances in chip design that may be commonplace 10 or 15 years from now **Low-Power CMOS Circuits** Christian Piguet,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 Piguet 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 **Low-Power CMOS Design for Wireless Transceivers** Alireza Zolfaghari,2003 This comprehensive treatment of the challenges in low power RF CMOS design deals with the design and implementation of low power wireless transceivers in a standard digital CMOS process It addresses trade offs and techniques that improve performance from the component level to the architectural level **Low Power Cmos Design** Chandrakasan A.,2000-01-01 This is an essential reference for achieving longer battery lifetimes for portable devices details a broad range of practical techniques for reducing power dissipation in integrated circuits It provides an excellent background for new researchers and

can serve as a comprehensive text book for graduate level courses      *Low-power HF Microelectronics* Gerson A. S. Machado,1996 This book brings together innovative modelling simulation and design techniques in CMOS SOI GaAs and BJT to achieve successful high yield manufacture for low power high speed and reliable by design analogue and mixed mode integrated systems      **The Electrical Engineering Handbook** Wai Kai Chen,2004-11-16 The Electrical Engineer s Handbook is an invaluable reference source for all practicing electrical engineers and students Encompassing 79 chapters this book is intended to enlighten and refresh knowledge of the practicing engineer or to help educate engineering students This text will most likely be the engineer s first choice in looking for a solution extensive complete references to other sources are provided throughout No other book has the breadth and depth of coverage available here This is a must have for all practitioners and students The Electrical Engineer s Handbook provides the most up to date information in Circuits and Networks Electric Power Systems Electronics Computer Aided Design and Optimization VLSI Systems Signal Processing Digital Systems and Computer Engineering Digital Communication and Communication Networks Electromagnetics and Control and Systems About the Editor in Chief Wai Kai Chen is Professor and Head Emeritus of the Department of Electrical Engineering and Computer Science at the University of Illinois at Chicago He has extensive experience in education and industry and is very active professionally in the fields of circuits and systems He was Editor in Chief of the IEEE Transactions on Circuits and Systems Series I and II President of the IEEE Circuits and Systems Society and is the Founding Editor and Editor in Chief of the Journal of Circuits Systems and Computers He is the recipient of the Golden Jubilee Medal the Education Award and the Meritorious Service Award from the IEEE Circuits and Systems Society and the Third Millennium Medal from the IEEE Professor Chen is a fellow of the IEEE and the American Association for the Advancement of Science 77 chapters encompass the entire field of electrical engineering THOUSANDS of valuable figures tables formulas and definitions Extensive bibliographic references      ,      **Power Aware Design Methodologies** Massoud Pedram,Jan M. Rabaey,2007-05-08 Power Aware Design Methodologies was conceived as an effort to bring all aspects of power aware design methodologies together in a single document It covers several layers of the design hierarchy from technology circuit logic and architectural levels up to the system layer It includes discussion of techniques and methodologies for improving the power efficiency of CMOS circuits digital and analog systems on chip microelectronic systems wirelessly networked systems of computational nodes and so on In addition to providing an in depth analysis of the sources of power dissipation in VLSI circuits and systems and the technology and design trends this book provides a myriad of state of the art approaches to power optimization and control The different chapters of Power Aware Design Methodologies have been written by leading researchers and experts in their respective areas Contributions are from both academia and industry The contributors have reported the various technologies methodologies and techniques in such a way that they are understandable and useful

**Low-power Architectural Design Methodologies** Paul Eric Landman,1994      **Thermal and Power Management of**

**Integrated Circuits** Arman Vassighi, Manoj Sachdev, 2006-06-01 In Thermal and Power Management of Integrated Circuits power and thermal management issues in integrated circuits during normal operating conditions and stress operating conditions are addressed Thermal management in VLSI circuits is becoming an integral part of the design test and manufacturing Proper thermal management is the key to achieve high performance quality and reliability Performance and reliability of integrated circuits are strong functions of the junction temperature A small increase in junction temperature may result in significant reduction in the device lifetime This book reviews the significance of the junction temperature as a reliability measure under nominal and burn in conditions The latest research in the area of electro thermal modeling of integrated circuits will also be presented Recent models and associated CAD tools are covered and various techniques at the circuit and system levels are reviewed Subsequently the authors provide an insight into the concept of thermal runaway and how it may best be avoided A section on low temperature operation of integrated circuits concludes the book *Integrated*

*Circuit and System Design* Enrico Macii, Vassilis Paliouras, Odysseas Koufopavlou, 2004-08-24

Welcome to the proceedings of PATMOS 2004 the fourteenth in a series of international workshops PATMOS 2004 was organized by the University of Patras with technical co sponsorship from the IEEE Circuits and Systems Society Over the years the PATMOS meeting has evolved into an important European event where industry and academia meet to discuss power and timing aspects in modern integrated circuit and system design PATMOS provides a forum for researchers to discuss and investigate the emerging challenges in sign methodologies and tools required to develop the upcoming generations of integrated circuits and systems We realized this vision this year by providing a technical program that contained state of the art technical contributions a keynote speech three invited talks and two embedded tutorials The technical program focused on timing performance and power consumption as well as architectural aspects with particular emphasis on modelling design characterization analysis and optimization in the nanometer era This year a record 152 contributions were received to be considered for possible presentation at PATMOS Despite the choice for an intense three day meeting only 51 lecture papers and 34 poster papers could be accommodated in the single track technical program The Technical Program Committee with the assistance of additional expert reviewers selected the 85 papers to be presented at PATMOS and organized them into 13 technical sessions As was the case with the PATMOS workshops the review process was anonymous full papers were required and several reviews were received per manuscript *Introduction to Low-Power Design in VLSIs* Patrick

Lee, 2011-12-12 This book discusses one increasingly important issue in the VLSI design low power It covers the following topics a basic concepts of low power design b low power design methods and applications in industry chips and c commercial CAD tools on low power design This book discusses the concepts a set of known methods industry cases and CAD tools on the low power design It is organized in four chapters and a glossary is provided at the end of the book *The Computer*

*Engineering Handbook* Vojin G. Oklobdzija, 2001-12-26 There is arguably no field in greater need of a comprehensive



handbook than computer engineering The unparalleled rate of technological advancement the explosion of computer applications and the now in progress migration to a wireless world have made it difficult for engineers to keep up with all the developments in specialties outside their own

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