

NEUROMORPHIC SYSTEMS ENGINEERING

Neural Networks in Silicon

**edited by
Tor Sverre Lande**



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Neuromorphic Systems Engineering Neural Networks In Silicon

Shahriar Rabbii, Bruce A. Wooley



Neuromorphic Systems Engineering Neural Networks In Silicon:

Neuromorphic Systems Engineering Tor Sverre Lande, 1998-04-30 Neuromorphic Systems Engineering Neural Networks in Silicon emphasizes three important aspects of this exciting new research field The term neuromorphic expresses relations to computational models found in biological neural systems which are used as inspiration for building large electronic systems in silicon By adequate engineering these silicon systems are made useful to mankind Neuromorphic Systems Engineering Neural Networks in Silicon provides the reader with a snapshot of neuromorphic engineering today It is organized into five parts viewing state of the art developments within neuromorphic engineering from different perspectives Neuromorphic Systems Engineering Neural Networks in Silicon provides the first collection of neuromorphic systems descriptions with firm foundations in silicon Topics presented include large scale analog systems in silicon neuromorphic silicon auditory ear and vision eye systems in silicon learning and adaptation in silicon merging biology and technology micropower analog circuit design analog memory analog interchipcommunication on digital buses LIST Neuromorphic Systems Engineering Neural Networks in Silicon serves as an excellent resource for scientists researchers and engineers in this emerging field and may also be used as a text for advanced courses on the subject **Neuromorphic Systems**

Engineering Tor Sverre Lande, 2014-01-15 *Neuromorphic Systems* Leslie S. Smith, Alister Hamilton, 1998 Neuromorphic systems are implementations in silicon of sensory and neural systems whose architecture and design are based on neurobiology This growing area proffers exciting possibilities such as sensory systems that can compete with human senses and pattern recognition systems that can run in real time The area is at the intersection of neurophysiology computer science and electrical engineering This book brings together recent developments in Europe and the US so that researchers in both academia and industry can find out about the state of the art As well as elementary material on what neuromorphic systems are and why they are growing in importance the book contains details of current work There are articles on aspects of implementing sensory neuromorphic systems as well as articles on neuromorphic hardware Event-Based Neuromorphic Systems Shih-Chii Liu, Tobi Delbruck, Giacomo Indiveri, Adrian Whatley, Rodney Douglas, 2015-02-16 Neuromorphic electronic engineering takes its inspiration from the functioning of nervous systems to build more power efficient electronic sensors and processors Event based neuromorphic systems are inspired by the brain's efficient data driven communication design which is key to its quick responses and remarkable capabilities This cross disciplinary text establishes how circuit building blocks are combined in architectures to construct complete systems These include vision and auditory sensors as well as neuronal processing and learning circuits that implement models of nervous systems Techniques for building multi chip scalable systems are considered throughout the book including methods for dealing with transistor mismatch extensive discussions of communication and interfacing and making systems that operate in the real world The book also provides historical context that helps relate the architectures and circuits to each other and that guides readers to the extensive literature Chapters are

written by founding experts and have been extensively edited for overall coherence This pioneering text is an indispensable resource for practicing neuromorphic electronic engineers advanced electrical engineering and computer science students and researchers interested in neuromorphic systems Key features Summarises the latest design approaches applications and future challenges in the field of neuromorphic engineering Presents examples of practical applications of neuromorphic design principles Covers address event communication retinas cochleas locomotion learning theory neurons synapses floating gate circuits hardware and software infrastructure algorithms and future challenges

Handbook of Memristor Networks Leon Chua, Georgios Ch. Sirakoulis, Andrew Adamatzky, 2019-11-12 This Handbook presents all aspects of memristor networks in an easy to read and tutorial style Including many colour illustrations it covers the foundations of memristor theory and applications the technology of memristive devices revised models of the Hodgkin Huxley Equations and ion channels neuromorphic architectures and analyses of the dynamic behaviour of memristive networks It also shows how to realise computing devices non von Neumann architectures and provides future building blocks for deep learning hardware With contributions from leaders in computer science mathematics electronics physics material science and engineering the book offers an indispensable source of information and an inspiring reference text for future generations of computer scientists mathematicians physicists material scientists and engineers working in this dynamic field

Neural Information Processing Tom Gedeon, Kok Wai Wong, Minho Lee, 2019-12-10 The three volume set of LNCS 11953 11954 and 11955 constitutes the proceedings of the 26th International Conference on Neural Information Processing ICONIP 2019 held in Sydney Australia in December 2019 The 173 full papers presented were carefully reviewed and selected from 645 submissions The papers address the emerging topics of theoretical research empirical studies and applications of neural information processing techniques across different domains The second volume LNCS 11954 is organized in topical sections on image processing by neural techniques learning from incomplete data model compression and optimisation neural learning models neural network applications and social network computing

Compact Low-Voltage and High-Speed CMOS, BiCMOS and Bipolar Operational Amplifiers Klaas-Jan de Langen, Johan Huijsing, 2013-03-14 Compact Low Voltage and High Speed CMOS BiCMOS and Bipolar Operational Amplifiers discusses the design of integrated operational amplifiers that approach the limits of low supply voltage or very high bandwidth The resulting realizations span the whole field of applications from micro power CMOS VLSI amplifiers to 1 GHz bipolar amplifiers The book presents efficient circuit topologies in order to combine high performance with simple solutions In total twelve amplifier realizations are discussed Two bipolar amplifiers are discussed a 1 GHz operational amplifier and an amplifier with a high ratio between the maximum output current and the quiescent current Five amplifiers have been designed in CMOS technology extremely compact circuits that can operate on supply voltages down to one gate source voltage and two saturation voltages which equals about 1.4 V and ultimate low voltage amplifiers that can operate on supply voltages down to one gate source voltage and one saturation

voltage which amounts to about 1.2 V. In BiCMOS technology five amplifiers have been designed. The first two amplifiers are based on a compact topology. Two other amplifiers are designed to operate on low supply voltages down to 1.3 V. The final amplifier has a unity gain frequency of 200 MHz and can operate down to 2.5 V. Compact Low Voltage and High Speed CMOS BiCMOS and Bipolar Operational Amplifiers is intended for the professional analog designer. Also it is suitable as a text book for advanced courses in amplifier design.

Integrated Microsystems Krzysztof Iniewski, 2017-12-19 As rapid technological developments occur in electronics, photonics, mechanics, chemistry, and biology, the demand for portable, lightweight integrated microsystems is relentless. These devices are getting exponentially smaller, increasingly used in everything from video games, hearing aids, and pacemakers to more intricate biomedical engineering and military applications. Edited by Kris Iniewski, a revolutionary in the field of advanced semiconductor materials, *Integrated Microsystems: Electronics, Photonics, and Biotechnology* focuses on techniques for optimized design and fabrication of these intelligent miniaturized devices and systems. Composed of contributions from experts in academia and industry around the world, this reference covers processes compatible with CMOS integrated circuits which combine computation, communications, sensing, and actuation capabilities. Light on math and physics with a greater emphasis on microsystem design and configuration and electrical engineering, this book is organized in three sections: Microelectronics and Biosystems, Photonics and Imaging, and Biotechnology and MEMs. It addresses key topics including physical and chemical sensing, imaging, smart actuation, and data fusion and management. Using tables, figures, and equations to help illustrate concepts, contributors examine and explain the potential of emerging applications for areas including biology, nanotechnology, microelectromechanical systems, MEMS, microfluidics, and photonics.

Amorphous Oxide Semiconductors Hideo Hosono, Hideya Kumomi, 2022-05-17 AMORPHOUS OXIDE SEMICONDUCTORS A singular resource on amorphous oxide semiconductors edited by a world recognized pioneer in the field. In *Amorphous Oxide Semiconductors: IGZO and Related Materials for Display and Memory*, the Editors deliver a comprehensive account of the current status of and latest developments in transparent oxide semiconductor technology. With contributions from leading international researchers and exponents in the field, this edited volume covers physical fundamentals, thin film transistor applications, processing, circuits, and device simulation, display and memory applications, and new materials relevant to amorphous oxide semiconductors. The book makes extensive use of structural diagrams, materials energy level and energy band diagrams, device structure illustrations, and graphs of device transfer characteristics, photographs, and micrographs to help illustrate the concepts discussed within. It also includes a thorough introduction to amorphous oxide semiconductors including discussions of commercial demand, common challenges faced during their manufacture, and materials design. Comprehensive explorations of the electronic structure of amorphous oxide semiconductors, structural randomness, doping limits, and defects. Practical discussions of amorphous oxide semiconductor processing including oxide materials and interfaces for application and

solution process metal oxide semiconductors for flexible electronics In depth examinations of thin film transistors TFTs including the trade off relationship between mobility and reliability in oxide TFTs Perfect for practicing scientists engineers and device technologists working with transparent semiconductor systems Amorphous Oxide Semiconductors IGZO and Related Materials for Display and Memory will also earn a place in the libraries of students studying oxides and other non classical and innovative semiconductor devices WILEY SID Series in Display Technology Series Editor Ian Sage Abelian Services Malvern UK The Society for Information Display SID is an international society which has the aim of encouraging the development of all aspects of the field of information display Complementary to the aims of the society the Wiley SID series is intended to explain the latest developments in information display technology at a professional level The broad scope of the series addresses all facets of information displays from technical aspects through systems and prototypes to standards and ergonomics

Smart Adaptive Systems on Silicon Maurizio Valle, 2004-10-18 Intelligent smart systems have become common practice in many engineering applications On the other hand current low cost standard CMOS technology and future foreseeable developments makes available enormous potentialities The next breakthrough will be the design and development of smart adaptive systems on silicon i e very power and highly size efficient complete systems i e sensing computing and actuating actions with intelligence on board on a single silicon die Smart adaptive systems on silicon will be able to adapt autonomously to the changing environment and will be able to implement intelligent behaviour and both perceptual and cognitive tasks At last they will communicate through wireless channels they will be battery supplied or remote powered via inductive coupling and they will be ubiquitous in our every day life Although many books deal with research and engineering topics i e algorithms technology implementations etc few of them try to bridge the gap between them and to address the issues related to feasibility reliability and applications Smart Adaptive Systems on Silicon though not exhaustive tries to fill this gap and to give answers mainly to the feasibility and reliability issues Smart Adaptive Systems on Silicon mainly focuses on the analog and mixed mode implementation on silicon because this approach is amenable of achieving impressive energy and size efficiency Moreover analog systems can be more easily interfaced with sensing and actuating devices

The Design of Low-Voltage, Low-Power Sigma-Delta Modulators Shahriar Rabii, Bruce A. Wooley, 2012-12-06 Oversampling techniques based on sigma delta modulation are widely used to implement the analog digital interfaces in CMOS VLSI technologies This approach is relatively insensitive to imperfections in the manufacturing process and offers numerous advantages for the realization of high resolution analog to digital A D converters in the low voltage environment that is increasingly demanded by advanced VLSI technologies and by portable electronic systems In The Design of Low Voltage Low Power Sigma Delta Modulators an analysis of power dissipation in sigma delta modulators is presented and a low voltage implementation of a digital audio performance A D converter based on the results of this analysis is described Although significant power savings can typically be achieved in digital circuits by reducing the power

supply voltage the power dissipation in analog circuits actually tends to increase with decreasing supply voltages. Oversampling architectures are a potentially power efficient means of implementing high resolution A/D converters because they reduce the number and complexity of the analog circuits in comparison with Nyquist rate converters. In fact it is shown that the power dissipation of a sigma delta modulator can approach that of a single integrator with the resolution and bandwidth required for a given application. In this research the influence of various parameters on the power dissipation of the modulator has been evaluated and strategies for the design of a power efficient implementation have been identified. *The Design of Low Voltage Low Power Sigma Delta Modulators* begins with an overview of A/D conversion emphasizing sigma delta modulators. It includes a detailed analysis of noise in sigma delta modulators, analyzes power dissipation in integrator circuits and addresses practical issues in the circuit design and testing of a high resolution modulator. *The Design of Low Voltage Low Power Sigma Delta Modulators* will be of interest to practicing engineers and researchers in the areas of mixed signal and analog integrated circuit design.

Top-Down Design of High-Performance Sigma-Delta Modulators

Fernando Medeiro, Belén Pérez Verdú, Ángel Rodríguez-Vázquez, 2013-04-18. The interest for $\Delta\Sigma$ modulation based NO converters has significantly increased in the last years. The reason for that is twofold. On the one hand, unlike other converters that need accurate building blocks to obtain high resolution $\Delta\Sigma$ converters show low sensitivity to the imperfections of their building blocks. This is achieved through extensive use of digital signal processing, a desirable feature regarding the implementation of $\Delta\Sigma$ interfaces in mainstream CMOS technologies which are better suited for implementing fast dense digital circuits than accurate analog circuits. On the other hand, the number of applications with industrial interest has also grown. In fact, starting from the earliest in the audio band, today we can find $\Delta\Sigma$ converters in a large variety of NO interfaces ranging from instrumentation to communications. These advances have been supported by a number of research works that have led to a considerably large amount of published papers and books covering different sub-topics from purely theoretical aspects to architecture and circuit optimization. However, so much material is often difficultly digested by those inexperienced designers who have been committed to developing a $\Delta\Sigma$ converter mainly because there is a lack of methodology. In our view, a clear methodology is necessary in $\Delta\Sigma$ modulator design because all related tasks are rather hard.

Highly Linear Integrated Wideband Amplifiers Henrik Sjöland, 2012-12-06. *Highly Linear Integrated Wideband Amplifiers: Design and Analysis Techniques for Frequencies from Audio to RF* deals with the complicated issues involved in the design of high linearity integrated wideband amplifiers for different operating frequencies. The book demonstrates these principles using a number of high performance designs. New topologies for high linearity are presented as well as a novel method for estimating the intermodulation distortion of a wideband signal. One of the most exciting results presented is an enhanced feedback configuration called feedback boosting that is capable of very low distortion. Also important is a statistical method for relating the intermodulation distortion of a wideband signal to the total harmonic distortion (THD) of a single tone. The THD

as opposed to the intermodulation distortion of the wideband signal is easy to measure and use as a design parameter Three different applications where high linearity is needed are identified namely audio power amplifiers wideband IF amplifiers and RF power amplifiers For these applications high performance integrated amplifier designs using novel topologies are presented together with measurement results The audio amplifiers are built in CMOS and are capable of driving 80Ω loads directly without using any external components One of the designs can operate on a supply voltage down to 1.5V Both bipolar and CMOS wideband IF amplifiers are built they are fully differential and have linearity from DC to 20 MHz Finally an RF power amplifier is built in CMOS without using inductors in order to investigate what performance can be achieved without them Highly Linear Integrated Wideband Amplifiers Design and Analysis Techniques for Frequencies from Audio to RF is an excellent reference for researchers and designers of integrated amplifiers and may be used as a text for advanced courses on the topic

CMOS Current Amplifiers Giuseppe Palmisano, Gaetano Palumbo, Salvatore Pennisi, 2012-12-06 CMOS Current Amplifiers presents design strategies for high performance current amplifiers based on CMOS technology After an introduction to various architectures of operational amplifiers the operating principles of the current amplifier are outlined This book provides the reader with simple and compact design equations for use in a pencil and paper design and the following simulation step Chapter 1 introduces the general aspects of current amplifiers After a preliminary classification of operational amplifiers ideal blocks and models are discussed for different architectures and a first high level comparison is made between traditional amplifiers and current amplifiers Analysis and examples of basic circuits as well as signal processing applications involving current amplifiers are also given Non idealities and second order effects causing limitations in performance are then discussed and evaluated Chapter 2 focuses on low drive current amplifiers Several design examples for current conveyors and class A current amplifiers are discussed in detail and design equations are presented for the main performance parameters which allows a good trade off between requirements High performance solutions for high bandwidth and low voltage capability are also considered and finally current comparators with progressively enhanced performance are reported and analyzed critically Chapter 3 deals with current amplifiers for off chip loads Several class AB current mode output stages are discussed and design strategies which improve performance are presented A detailed analysis of non ideal effect is carried out with particular emphasis on linearity Design examples are given and circuit arrangements for further developments are included CMOS Current Amplifiers serves as an excellent reference for researchers and professionals of analog IC design and may also be used as an advanced text on current amplifiers

Distortion Analysis of Analog Integrated Circuits Piet Wambacq, Willy M.C. Sansen, 2013-04-17 The analysis and prediction of nonlinear behavior in electronic circuits has long been a topic of concern for analog circuit designers The recent explosion of interest in portable electronics such as cellular telephones cordless telephones and other applications has served to reinforce the importance of these issues The need now often arises to predict and optimize the

distortion performance of diverse electronic circuit configurations operating in the gigahertz frequency range where nonlinear reactive effects often dominate. However, there have historically been few sources available from which design engineers could obtain information on analysis techniques suitable for tackling these important problems. I am sure that the analog circuit design community will thus welcome this work by Dr Wambacq and Professor Sansen as a major contribution to the analog circuit design literature in the area of distortion analysis of electronic circuits. I am personally looking forward to having a copy readily available for reference when designing integrated circuits for communication systems.

Continuous-Time Delta-Sigma Modulators for High-Speed A/D Conversion James A. Cherry, W. Martin

Snelgrove, 2006-04-18 Among analog to digital converters the delta sigma modulator has cornered the market on high to very high resolution converters at moderate speeds with typical applications such as digital audio and instrumentation. Interest has recently increased in delta sigma circuits built with a continuous time loop filter rather than the more common switched capacitor approach. Continuous time delta sigma modulators offer less noisy virtual ground nodes at the input, inherent protection against signal aliasing and the potential to use a physical rather than an electrical integrator in the first stage for novel applications like accelerometers and magnetic flux sensors. More significantly they relax settling time restrictions so that modulator clock rates can be raised. This opens the possibility of wideband 1 MHz or more converters possibly for use in radio applications at an intermediate frequency so that one or more stages of mixing might be done in the digital domain.

Continuous Time Delta Sigma Modulators for High Speed A/D Conversion: Theory, Practice and Fundamental Performance Limits covers all aspects of continuous time delta sigma modulator design with particular emphasis on design for high clock speeds. The authors explain the ideal design of such modulators in terms of the well understood discrete time modulator design problem and provide design examples in Matlab. They also cover commonly encountered non-idealities in continuous time modulators and how they degrade performance, plus a wealth of material on the main problems: feedback path delays, clock jitter and quantizer metastability in very high speed designs and how to avoid them. They also give a concrete design procedure for a real high speed circuit which illustrates the tradeoffs in the selection of key parameters. Detailed circuit diagrams, simulation results and test results for an integrated continuous time 4 GHz band pass modulator for A/D conversion of 1 GHz analog signals are also presented.

Continuous Time Delta Sigma Modulators for High Speed A/D Conversion: Theory, Practice and Fundamental Performance Limits concludes with some promising modulator architectures and a list of the challenges that remain in this exciting field.

Analog VLSI Shih-Chii Liu, 2002 An introduction to the design of analog VLSI circuits. Neuromorphic engineers work to improve the performance of artificial systems through the development of chips and systems that process information collectively using primarily analog circuits. This book presents the central concepts required for the creative and successful design of analog VLSI circuits. The discussion is weighted toward novel circuits that emulate natural signal processing. Unlike most circuits in commercial or industrial applications, these circuits operate mainly

in the subthreshold or weak inversion region Moreover their functionality is not limited to linear operations but also encompasses many interesting nonlinear operations similar to those occurring in natural systems Topics include device physics linear and nonlinear circuit forms translinear circuits photodetectors floating gate devices noise analysis and process technology

Analog Layout Generation for Performance and Manufacturability Koen Lampaert, Georges Gielen, Willy M.C. Sansen, 2013-04-18 Analog integrated circuits are very important as interfaces between the digital parts of integrated electronic systems and the outside world A large portion of the effort involved in designing these circuits is spent in the layout phase Whereas the physical design of digital circuits is automated to a large extent the layout of analog circuits is still a manual time consuming and error prone task This is mainly due to the continuous nature of analog signals which causes analog circuit performance to be very sensitive to layout parasitics The parasitic elements associated with interconnect wires cause loading and coupling effects that degrade the frequency behaviour and the noise performance of analog circuits Device mismatch and thermal effects put a fundamental limit on the achievable accuracy of circuits For successful automation of analog layout advanced place and route tools that can handle these critical parasitics are required In the past automatic analog layout tools tried to optimize the layout without quantifying the performance degradation introduced by layout parasitics Therefore it was not guaranteed that the resulting layout met the specifications and one or more layout iterations could be needed In Analog Layout Generation for Performance and Manufacturability the authors propose a performance driven layout strategy to overcome this problem In this methodology the layout tools are driven by performance constraints such that the final layout with parasitic effects still satisfies the specifications of the circuit The performance degradation associated with an intermediate layout solution is evaluated at runtime using predetermined sensitivities In contrast with other performance driven layout methodologies the tools proposed in this book operate directly on the performance constraints without an intermediate parasitic constraint generation step This approach makes a complete and sensible trade off between the different layout alternatives possible at runtime and therefore eliminates the possible feedback route between constraint derivation placement and layout extraction Besides its influence on the performance layout also has a profound impact on the yield and testability of an analog circuit In Analog Layout Generation for Performance and Manufacturability the authors outline a new criterion to quantify the detectability of a fault and combine this with a yield model to evaluate the testability of an integrated circuit layout They then integrate this technique with their performance driven routing algorithm to produce layouts that have optimal manufacturability while still meeting their performance specifications Analog Layout Generation for Performance and Manufacturability will be of interest to analog engineers researchers and students

Handbook of Nature-Inspired and Innovative Computing Albert Y. Zomaya, 2006-01-10 As computing devices proliferate demand increases for an understanding of emerging computing paradigms and models based on natural phenomena Neural networks evolution based models quantum computing and DNA based computing and

simulations are all a necessary part of modern computing analysis and systems development Vast literature exists on these new paradigms and their implications for a wide array of applications This comprehensive handbook the first of its kind to address the connection between nature inspired and traditional computational paradigms is a repository of case studies dealing with different problems in computing and solutions to these problems based on nature inspired paradigms The Handbook of Nature Inspired and Innovative Computing Integrating Classical Models with Emerging Technologies is an essential compilation of models methods and algorithms for researchers professionals and advanced level students working in all areas of computer science IT biocomputing and network engineering

Artificial Neural Networks: Biological Inspirations - ICANN 2005 Włodzisław Duch, 2005 The two volume set LNCS 3696 and LNCS 3697 constitutes the refereed proceedings of the 15th International Conference on Artificial Neural Networks ICANN 2005 held in Warsaw Poland in September 2005 The over 600 papers submitted to ICANN 2005 were thoroughly reviewed and carefully selected for presentation The first volume includes 106 contributions related to Biological Inspirations topics addressed are modeling the brain and cognitive functions development of cognitive powers in embodied systems spiking neural networks associative memory models models of biological functions projects in the area of neuroIT evolutionary and other biological inspirations self organizing maps and their applications computer vision face recognition and detection sound and speech recognition bioinformatics biomedical applications and information theoretic concepts in biomedical data analysis The second volume contains 162 contributions related to Formal Models and their Applications and deals with new neural network models supervised learning algorithms ensemble based learning unsupervised learning recurrent neural networks reinforcement learning bayesian approaches to learning learning theory artificial neural networks for system modeling decision making optimization and control knowledge extraction from neural networks temporal data analysis prediction and forecasting support vector machines and kernel based methods soft computing methods for data representation analysis and processing data fusion for industrial medical and environmental applications non linear predictive models for speech processing intelligent multimedia and semantics applications to natural language processing various applications computational intelligence in games and issues in hardware implementation

Whispering the Strategies of Language: An Psychological Journey through **Neuromorphic Systems Engineering Neural Networks In Silicon**

In a digitally-driven world wherever displays reign great and quick interaction drowns out the subtleties of language, the profound techniques and emotional subtleties hidden within phrases frequently move unheard. However, situated within the pages of **Neuromorphic Systems Engineering Neural Networks In Silicon** a interesting literary treasure sporting with organic feelings, lies an exceptional quest waiting to be undertaken. Composed by an experienced wordsmith, that enchanting opus invites viewers on an introspective journey, softly unraveling the veiled truths and profound influence resonating within the very cloth of each and every word. Within the psychological depths with this touching evaluation, we shall embark upon a honest exploration of the book is key subjects, dissect their interesting writing fashion, and fail to the strong resonance it evokes serious within the recesses of readers hearts.

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