

# **DESIGN OF LOW-VOLTAGE, LOW-POWER OPERATIONAL AMPLIFIER CELLS**

**Ron Hogervorst  
Johan H. Huijsing**

**Springer-Science+Business Media, B.V.**

# Design Of Low Voltage Low Power Operational Amplifier Cells The Springer International Series In Engineering And Computer Science

**Fernando Medeiro,Belén Pérez  
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## **Design Of Low Voltage Low Power Operational Amplifier Cells The Springer International Series In Engineering And Computer Science:**

*Design of Low-Voltage, Low-Power Operational Amplifier Cells* Ron Hogervorst, Johan Huijsing, 2013-03-09 Design of Low Voltage Low Power CMOS Operational Amplifier Cells describes the theory and design of the circuit elements that are required to realize a low voltage low power operational amplifier These elements include constant gm rail to rail input stages class AB rail to rail output stages and frequency compensation methods Several examples of each of these circuit elements are investigated Furthermore the book illustrates several silicon realizations giving their measurement results The text focuses on compact low voltage low power operational amplifiers with good performance Six simple high performance class AB amplifiers are realized using a very compact topology making them particularly suitable for use as VLSI library cells All of the designs can use a supply voltage as low as 3V One of the amplifier designs dissipates only 50 W with a unity gain frequency of 1.5 MHz A second set of amplifiers run on a supply voltage slightly above 1V The amplifiers combine a low power consumption with a gain of 120 dB In addition the design of three fully differential operational amplifiers is addressed Design of Low Voltage Low Power CMOS Operational Amplifier Cells is intended for professional designers of analog circuits It is also suitable for use as a text book for an advanced course in CMOS operational amplifier design **International**

**Books in Print**, 1997 *Vision Chips* Alireza Moini, 2012-12-06 This chapter presents a set of introductory material which in addition to providing a general view on the topic highlights the importance of research in this area It also presents a short history of the design of smart vision sensors and points out some of the fundamental issues in the design of such sensors 1.1 A General Overview Machine vision is one of the main branches of artificial intelligence The richness of information present in images makes them the first choice as an input to an artificial system which tries to interact with its environment A large proportion of the brain of many advanced species is dedicated to visual information processing which illustrates the importance of visual information in biological systems Biological visual systems have evolved over millions of years and each species has developed a specialized visual system tailored for the essential tasks of survival such as catching a prey or escaping a predator Implementing electronic hardware for image processing therefore may benefit from the underlying fundamental aspects of biological vision though in no respect should this be regarded as a solid framework for electronic vision systems Traditionally computer vision algorithms are performed on images captured by conventional cameras and processing is accomplished by means of general purpose digital computers More advanced systems utilize dedicated hardware to speed up the processing stage *Proceedings of International Conference on Advanced Computing Applications* Jyotsna Kumar Mandal, Rajkumar Buyya, Debashis De, 2021-11-23 This book gathers selected high quality research papers presented at the 2nd International Conference on Advanced Computing Applications ICACA 2021 held virtually during 27-28 March 2021 The book is divided into four sections These are communication and computing signal

processing and multimedia computational intelligence and data analytics and decision computing The topics covered are advanced communication technologies IoT based systems and applications network security and reliability virtualization technologies compressed sensors and multimedia applications signal image and video processing machine learning pattern recognitions intelligent computing big data analytics analytics in bio computing AI driven 6G mobile wireless networks and autonomous driving

**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

Intelligent System Design Suresh Chandra Satapathy, Vikrant Bhateja, B.

Janakiramaiah, Yen-Wei Chen, 2020-08-10 This book presents a collection of high quality peer reviewed research papers from the 6th International Conference on Information System Design and Intelligent Applications INDIA 2019 held at Lendi Institute of Engineering Technology India from 1 to 2 November 2019 It covers a wide range of topics in computer science and information technology including data mining and data warehousing high performance computing parallel and distributed computing computational intelligence soft computing big data cloud computing grid computing and cognitive computing

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.

**Electrical and Electronic Devices, Circuits, and Materials** Suman Lata Tripathi, Parvej Ahmad Alvi, Umashankar Subramaniam, 2021-03-24

The increasing demand for electronic devices for private and industrial purposes lead designers and researchers to explore new electronic devices and circuits that can perform several tasks efficiently with low IC area and low power consumption. In addition, the increasing demand for portable devices intensifies the call from industry to design sensor elements, an efficient storage cell, and large capacity memory elements. Several industry related issues have also forced a redesign of basic electronic components for certain specific applications. The researchers, designers, and students working in the area of electronic devices, circuits, and materials sometimes need standard examples with certain specifications. This breakthrough work presents this knowledge of standard electronic device and circuit design analysis.

including advanced technologies and materials This outstanding new volume presents the basic concepts and fundamentals behind devices circuits and systems It is a valuable reference for the veteran engineer and a learning tool for the student the practicing engineer or an engineer from another field crossing over into electrical engineering It is a must have for any library

**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

Neuromorphic Systems Engineering Tor Sverre Lande,2007-08-26 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

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

**Learning on Silicon** G. Cauwenberghs, Magdy Bayoumi, 1999-06-30 Learning on Silicon combines models of adaptive information processing in the brain with advances in microelectronics technology and circuit design The premise is to construct integrated systems not only loaded with sufficient computational power to handle demanding signal processing tasks in sensory perception and pattern recognition but also capable of operating autonomously and robustly in unpredictable environments through mechanisms of adaptation and learning This edited volume covers the

spectrum of Learning on Silicon in five parts adaptive sensory systems neuromorphic learning learning architectures learning dynamics and learning systems The 18 chapters are documented with examples of fabricated systems experimental results from silicon and integrated applications ranging from adaptive optics to biomedical instrumentation As the first comprehensive treatment on the subject Learning on Silicon serves as a reference for beginners and experienced researchers alike It provides excellent material for an advanced course and a source of inspiration for continued research towards building intelligent adaptive machines

*Top-Down Design of High-Performance Sigma-Delta Modulators* Fernando Medeiro, Belén Pérez Verdú, Angel Rodríguez-Vázquez, 2013-04-18 The interest for  $\Sigma\Delta$  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  $\Sigma\Delta$  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 NO 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  $\Sigma\Delta$  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 lead 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 unexperienced designers who have been committed to developing a  $\Sigma\Delta$  converter mainly because there is a lack of methodology In our view a clear methodology is necessary in  $\Sigma\Delta$  modulator design because all related tasks are rather hard

**Design of Modulators for Oversampled Converters** Feng Wang, Ramesh Harjani, 2012-12-06 Oversampled A/D converters have become very popular in recent years Some of their advantages include relaxed requirements for anti alias filters relaxed requirements for component matching high resolution and compatibility with digital VLSI technology There is a significant amount of literature discussing the principle theory and implementation of various oversampled converters Such converters are likely to continue to proliferate in the foreseeable future Additionally more recently there has been great interest in low voltage and low power circuit design New design techniques have been proposed for both the digital domain and the analog domain Both trends point to the importance of the low power design of oversampled A/D converters Unfortunately there has been no systematic study of the optimal design of modulators for oversampled converters Design has generally focused on new architectures with little attention being paid to optimization The goal of Design of Modulators for Oversampled Converters is to develop a methodology for the optimal design of modulators in oversampled converters The primary focus of the presentation is on minimizing power consumption and understanding and limiting the nonlinearities that result in such converters Design of Modulators for Oversampled Converters offers a quantitative justification for the various design



tradeoffs and serves as a guide for designing low power highly linear oversampled converters Design of Modulators for Oversampled Converters will serve as a valuable guide for circuit design practitioners university researchers and graduate students who are interested in this fast moving area

**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 8Ω loudspeaker 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

*Symbolic Analysis in Analog Integrated Circuit Design* Henrik Floberg, 2012-12-06 Symbolic Analysis in Analog Integrated Circuit Design provides an introduction to computer aided circuit analysis and presents systematic methods for solving linear i.e. small signal and nonlinear circuit problems which are illustrated by concrete examples Computer aided symbolic circuit analysis is useful in analog integrated circuit design Analytic expressions for the network transfer functions contain information that is not provided by a numerical simulation result However these expressions are generally extremely long and difficult to interpret therefore it is necessary to be able to approximate them guided by the magnitude of the individual circuit parameters Engineering has been described as the art of making approximations The inclusion of symbolic analysis in analog circuit design reduces the implied risk of ambiguity during the approximation process A systematic method based on the nullor concept is used to obtain the basic feedback transistor amplifier configurations Approximate expressions for the locations of poles and zeros for linear networks are obtained using the extended pole splitting technique An unusual feature in Symbolic Analysis in Analog Integrated Circuit Design is the consistent use of the transadmittance element with finite

linear or nonlinear or infinite i.e. null or gain as the only requisite circuit element. The describing function method is used to obtain approximate symbolic expressions for the harmonic distortion generated by a soft or hard transconductance nonlinearity embedded in an arbitrary linear network. The design and implementation of a program i.e. CASCA for symbolic analysis of time continuous networks is described. The algorithms can also be used to solve other linear problems e.g. the analysis of time discrete switched capacitor networks. Symbolic Analysis in Analog Integrated Circuit Design serves as an excellent resource for students and researchers as well as for industry designers who want to familiarize themselves with circuit analysis. This book may also be used for advanced courses on the subject.

*Design Criteria for Low Distortion in Feedback Opamp Circuits* Bjørnar Hernes, Trond Sæther, 2006-04-18. Broadband opamps for multi channel communication systems make strong demands on linearity performance. This book written for Analog CMOS designers presents a thorough analysis of the nonlinear behaviour of circuits to obtain opamps with low distortion.

*Proceedings of the Fifth International Conference on Trends in Computational and Cognitive Engineering* M. Shamim Kaiser, Raghvendra Singh, Anirban Bandyopadhyay, Mufti Mahmud, Kanad Ray, 2025-07-04. This book presents various computational and cognitive modeling approaches in the areas of health education finance environment engineering commerce and industry. It is a collection of selected conference papers presented at the 5th International Conference on Trends in Cognitive Computation Engineering TCCE 2023 organized by Pranveer Singh Institute of Technology Kanpur Uttar Pradesh India in collaboration with IIOIR Shimla Himachal Pradesh India during 24-25 November 2023. The book is divided into two volumes and it shares cutting edge insights and ideas from mathematicians engineers scientists and researchers and discusses fresh perspectives on problem solving in a range of research areas.

**Proceedings of the 2nd International Conference on Emerging Technologies and Intelligent Systems** Mohammed A. Al-Sharafi, Mostafa Al-Emran, Mohammed Naji Al-Kabi, Khaled Shaalan, 2022-12-12. This book sheds light on the recent research directions in intelligent systems and their applications. It involves four main themes: artificial intelligence and data science, recent trends in software engineering, emerging technologies in education and intelligent health informatics. The discussion of the most recent designs, advancements and modifications of intelligent systems as well as their applications is a key component of the chapters contributed to the aforementioned subjects.

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