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

Ron Hogervorst Johan H. Huijsing

# **Design Of Low Voltage Low Power Operational Amplifier Cells**

Alireza Moini

# **Design Of Low Voltage Low Power Operational Amplifier Cells:**

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 Design of **Low-voltage Low-power CMOS Operational Amplifier Cells** Ron Hogervorst, 1996 The Design of Low-Voltage. Low-Power Sigma-Delta Modulators Shahriar Rabii, Bruce A. Wooley, 1999 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 Low-Voltage/Low-Power Integrated Circuits and Systems Edgar Sánchez-Sinencio, Andreas G. Andreou, 1999-01-13 Electrical Engineering Low Voltage Low Power Integrated Circuits and Systems Low Voltage Mixed Signal Circuits Leading experts in the field present this collection of original contributions as a practical approach to low power analog and digital circuit theory and design illustrated with important applications and examples Low Voltage Low Power Integrated Circuits and Systems features comprehensive coverage of the latest techniques for the design modeling and characterization of low power analog and digital circuits Low Voltage Low Power Integrated Circuits and Systems will help you improve your understanding of the trade offs between analog and digital circuits and systems It is an invaluable resource for enhancing your designs This book is intended for senior and graduate students It is also intended as a key reference for designers in the semiconductor and communication industries Highlighted applications include Low voltage analog filters Low power multiplierless YUV to RGB based on human vision perception Micropower systems for implantable defibrillators and pacemakers Neuromorphic systems Low power design in telecom circuits A Design Strategy for Low-power Low-voltage Integrated Transconductance **Amplifiers** Jeroen Cornelis Kuenen, 1997 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 tech niques 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 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

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 **Dynamic Translinear and Log-Domain Circuits** Jan Mulder, Wouter A. Serdijn, Albert C. van der Woerd, Arthur H.M. van Roermund, 2012-12-06 Log domain and translinear filters provide a competitive alternative to the challenges of ever increasing low voltage low power and high frequency demands in the area of continuous time filters Since translinear filters are fundamentally large signal linear they are capable of realizing a large dynamic range in combination with excellent tunability characteristics Large signal linearity is achieved by exploiting the accurate exponential behavior of the bipolar transistor or the subthreshold MOS transistor A generalization of the dynamic translinear principle exploiting the square law behavior of the MOS transistor is theoretically possible but not practically relevant Translinear and log domain filters are based on the dynamic translinear principle a generalization of the conventional static translinear principle Besides their application for linear filters dynamic translinear circuits can also be used for the realization of non linear dynamic functions such as oscillators RMS DC converters and phase locked loops Dynamic Translinear and Log Domain Circuits Analysis and Synthesis covers both the analysis and synthesis of translinear circuits The theory is presented using one unifying framework for both static and dynamic translinear networks which is based on a current mode approach General analysis methods are presented including the large signal and non stationary analysis of noise A well structured synthesis method is described greatly enhancing the designability of log domain and translinear circuits Comparisons are made with respect to alternative analysis and synthesis methods presented in the literature The theory is illustrated and verified by various examples and realizations Dynamic Translinear and Log Domain Circuits Analysis and Synthesis is an excellent reference for researchers and circuit designers and may be used as a text for Design of Low-Voltage Bipolar Operational Amplifiers M. Jeroen Fonderie, Johan advanced courses on the topic Huijsing, 2012-12-22 Design of Low Voltage Bipolar Operational Amplifiers discusses the sub circuits necessary to build a low voltage operational amplifier These include rail to rail input stages rail to rail output stages intermediate stages protection circuitry and frequency compensation techniques Of each of these various implementations are examined Furthermore the

book discusses realizations in silicon of the amplifiers The design and implementation of low voltage bipolar Operational Amplifiers OpAmps is fully presented A low supply voltage is necessary because the tendency towards chip components of smaller dimensions lowers the breakdown voltage of these components Further a low supply voltage is favorable because it enables operation of the OpAmp from just one single battery cell The bipolar technology is chosen because it is more suited for operation at low voltages than the MOS technology The common mode input voltage of the OpAmp must be able to have any value that fits within the supply voltage range Input stages are discussed which are able to realize this at supply voltages down to 1 8 V as well as down to 1 V The output voltage of the OpAmp must be able to have any value within the supply voltage range One of the 1 V output stages that is discussed the multi path driven output stage also has a high bandwidth with a high gain In addition to the input and output stage the OpAmp comprises an intermediate stage between the input stage and the output stage to boost the overall gain of the OpAmp and a class AB current control A frequency compensation technique is used to split apart the pole frequencies in the transfer function A disadvantage of this nested Miller compensation is that the resulting bandwidth is reduced by a factor of two A new method multi path driven Miller compensation which does not have this drawback is therefore introduced Several realizations are evaluated and a figure of merit is defined for the performance comparison of the OpAmps One of the OpAmps operates at a 1 V supply has a 3 4 MHz bandwidth with a 100 pF load and has a 700 A supply current The book is an excellent reference for professional designers of amplifiers and may be used as a text for advanced courses on the subject **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 specie 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 Low-voltage and Low-power, Deep-submicron Analog Circuits for Single-chip, Mixed-signal Microinstrumentation Systems Keith L. Kraver, 2004

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