

FREQUENCY COMPENSATION TECHNIQUES FOR LOW-POWER OPERATIONAL AMPLIFIERS

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Kluwer Academic Publishers

Frequency Compensation Techniques For Low Power Operational Amplifiers

Klaas-Jan de Langen, Johan Huijsing



Frequency Compensation Techniques For Low Power Operational Amplifiers:

Frequency Compensation Techniques for Low-Power Operational Amplifiers Rudy G.H. Eschauzier, Johan Huijsing, 2013-04-17 Frequency Compensation Techniques for Low Power Operational Amplifiers is intended for professional designers of integrated amplifiers emphasizing low voltage and low power solutions The book bridges the gap between the professional designer's needs and available techniques for frequency compensation It does so by explaining existing techniques and introducing several new techniques including Hybrid Nested Miller compensation Multipath Miller Zero cancellation and Multipath Conditionally Stable compensation All compensation techniques are treated in a stage number based order progressing from a single transistor to circuits with six stages and more Apart from discussing the mathematical basis of the compensation methods the book provides the reader with the factual information that is required for practicing the design of integrated feedback amplifiers and many worked out examples What is more many bipolar and CMOS operational amplifier realizations along with their measurement results prove the effectiveness of the compensation techniques in real life circuits The text focuses on low voltage low power integrated amplifiers Many of the presented bipolar circuits operate at supply voltages down to 1V while several CMOS amplifiers that function correctly just slightly above this voltage are demonstrated The lowest measured power consumption amounts to 17μW for a class AB CMOS opAmp with 120dB gain Despite this attention to low voltage and low power the frequency compensation strategies provided are universally applicable The fundamental approach followed leads to efficient compensation strategies that are well guarded against the parameter variations inherent to the mass fabrication of integrated circuits The book is essential reading for practicing analog design engineers and researchers in the field It is also suitable as a text for an advanced course on the subject

Frequency Compensation Techniques for Low-Power Operational Amplifiers Rudy G. H. Eschauzier, Johan Huijsing, 2014-01-15

Operational Amplifiers Johan Huijsing, 2011-04-23 Operational Amplifiers Theory and Design Second Edition presents a systematic circuit design of operational amplifiers Containing state of the art material as well as the essentials the book is written to appeal to both the circuit designer and the system designer It is shown that the topology of all operational amplifiers can be divided into nine main overall configurations These configurations range from one gain stage up to four or more stages Many famous designs are evaluated in depth Additional chapters included are on systematic design of V offset operational amplifiers and precision instrumentation amplifiers by applying chopping auto zeroing and dynamic element matching techniques Also techniques for frequency compensation of amplifiers with high capacitive loads have been added Operational Amplifiers Theory and Design Second Edition presents high frequency compensation techniques to HF stabilize all nine configurations Special emphasis is placed on low power low voltage architectures with rail to rail input and output ranges In addition to presenting characterization of operational amplifiers by macro models and error matrices together with measurement techniques for their parameters it also develops the design of fully differential

operational amplifiers and operational floating amplifiers Operational Amplifiers Theory and Design Second Edition is carefully structured and enriched by numerous figures problems and simulation exercises and is ideal for the purpose of self study and self evaluation

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

Integrated Circuit and System Design. Power and Timing Modeling, Optimization and Simulation Lars Svensson, José Monteiro, 2009-01-30 Welcome to the proceedings of PATMOS 2008 the 18th in a series of international workshops PATMOS 2008 was organized by INESC ID IST TU Lisbon Portugal with sponsorship by Cadence IBM Chipidea and Tecmic and technical co sponsorship by the IEEE Over the years PATMOS has evolved into an important European event where researchers from both industry and academia discuss and investigate the emerging challenges in future and contemporary applications design methodologies and tools required for the development of the upcoming generations of integrated circuits and systems The technical program of PATMOS 2008 contained state of the art technical contributions three invited talks and a special session on reconfigurable architectures The technical program focused on timing performance and power consumption as well as architectural aspects with particular emphasis on modeling design characterization analysis and optimization in the nanometer era The Technical Program Committee with the assistance of additional expert reviewers selected the 41 papers presented at PATMOS The papers were organized into 7 oral sessions with a total of 31 papers and 2 poster sessions with a total of 10 papers As is customary for the PATMOS workshops full papers were required for review and a minimum of three reviews were received per manuscript

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 Circuit and System Design. Power and Timing Modeling, Optimization and Simulation Nadine Azemard, Lars Svensson, 2007-08-21 This volume features the refereed proceedings of the 17th International Workshop on Power and Timing Modeling Optimization and Simulation Papers cover high level design low power design techniques low power analog circuits statistical static timing analysis power modeling and optimization low power routing optimization security and asynchronous design low power applications modeling and optimization and more

Sensors and Low Power Signal Processing Syed Kamrul Islam, Mohammad Rafiqul Haider, 2009-12-02 Low power sensors and their applications in various fields ranging from military to civilian lives have made tremendous progress in the recent years Low power and extended battery life are the key focuses for long term reliable and easy operation of these sensors Sensors and Low Power Signal Processing provides a general overview of a sensor's working principle and a discussion of the emerging sensor technologies including chemical electro chemical and MEMS based sensors Also included is a discussion on design challenges associated with low power analog circuits and the schemes to overcome them Finally a short discussion of some of the simple wireless telemetry schemes best suited for low power sensor applications and sensor packaging issues is discussed Applications and sensor prototypes included are environmental monitoring health care monitoring and issues related to the development of sensor prototypes and associated electronics to achieve high signal to noise ratio will also be presented

Low Power Analog CMOS for Cardiac Pacemakers Fernando Silveira, Denis Flandre, 2013-03-09 Low Power Analog CMOS for Cardiac Pacemakers proposes new techniques for the reduction of power consumption in analog integrated circuits Our main example is the pacemaker sense channel which is representative of a broader class of biomedical circuits aimed at qualitatively detecting biological signals The first and second chapters are a tutorial presentation on implantable medical devices and pacemakers from the circuit designer point of view This is illustrated by the requirements and solutions applied in our implementation of an industrial IC for pacemakers

There from the book discusses the means for reduction of power consumption at three levels base technology power oriented analytical synthesis procedures and circuit architecture

High-speed, Low-power Multi-stage Operational Amplifiers with Advanced Frequency Compensation Techniques Mohammad Nizam Kabir,2002 [Analysis and Design of Analog Integrated Circuits](#) Paul R. Gray,Paul J. Hurst,Stephen H. Lewis,Robert G. Meyer,2024-01-04 ANALYSIS AND DESIGN OF ANALOG INTEGRATED CIRCUITS Authoritative and comprehensive textbook on the fundamentals of analog integrated circuits with learning aids included throughout Written in an accessible style to ensure complex content can be appreciated by both students and professionals this Sixth Edition of Analysis and Design of Analog Integrated Circuits is a highly comprehensive textbook on analog design offering in depth coverage of the fundamentals of circuits in a single volume To aid in reader comprehension and retention supplementary material includes end of chapter problems plus a Solution Manual for instructors In addition to the well established concepts this Sixth Edition introduces a new super source follower circuit and its large signal behavior frequency response stability and noise properties New material also introduces replica biasing describes and analyzes two op amps with replica biasing and provides coverage of weighted zero value time constants as a method to estimate the location of dominant zeros pole zero doublets including their effect on settling time and three examples of circuits that create doublets the effect of feedback on pole zero doublets and MOS transistor noise performance including a thorough treatment on thermally induced gate noise Providing complete coverage of the subject Analysis and Design of Analog Integrated Circuits serves as a valuable reference for readers from many different types of backgrounds including senior undergraduates and first year graduate students in electrical and computer engineering along with analog integrated circuit designers

CMOS Analog Design Using All-Region MOSFET Modeling Márcio Cherem Schneider,Carlos Galup-Montoro,2010-01-28 The essentials of analog circuit design with a unique all region MOSFET modeling approach

Operational Amplifier Speed and Accuracy Improvement Vadim V. Ivanov,Igor M. Filanovsky,2005-12-30 Operational Amplifier Speed and Accuracy Improvement proposes a new methodology for the design of analog integrated circuits The usefulness of this methodology is demonstrated through the design of an operational amplifier This methodology consists of the following iterative steps description of the circuit functionality at a high level of abstraction using signal flow graphs equivalent transformations and modifications of the graph to the form where all important parameters are controlled by dedicated feedback loops and implementation of the structure using a library of elementary cells Operational Amplifier Speed and Accuracy Improvement shows how to choose structures and design circuits which improve an operational amplifier s important parameters such as speed to power ratio open loop gain common mode voltage rejection ratio and power supply rejection ratio The same approach is used to design clamps and limiting circuits which improve the performance of the amplifier outside of its linear operating region such as slew rate enhancement output short circuit current limitation and input overload recovery

[Ultra Low Power Bioelectronics](#) Rahul Sarpeshkar,2010-02-22

This book provides for the first time a broad and deep treatment of the fields of both ultra low power electronics and bioelectronics. It discusses fundamental principles and circuits for ultra low power electronic design and their applications in biomedical systems. It also discusses how ultra energy efficient cellular and neural systems in biology can inspire revolutionary low power architectures in mixed signal and RF electronics. The book presents a unique unifying view of ultra low power analog and digital electronics and emphasizes the use of the ultra energy efficient subthreshold regime of transistor operation in both. Chapters on batteries, energy harvesting and the future of energy provide an understanding of fundamental relationships between energy use and energy generation at small scales and at large scales. A wealth of insights and examples from brain implants, cochlear implants, bio molecular sensing, cardiac devices and bio inspired systems make the book useful and engaging for students and practicing engineers.

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.

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 μ 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 μ W Design of Low Voltage Low Power CMOS Delta Sigma A/D Converters is essential reading for analog design engineers and researchers

Switched-Capacitor Techniques for High-Accuracy Filter and ADC Design Patrick J. Quinn, Arthur H.M. van Roermund, 2007-07-20 This book proposes alternative switched capacitor techniques which allow the achievement of higher intrinsic analogue functional accuracy than previously possible in such application areas as analogue filter and ADC design The validity of the concepts developed and analyzed in Switched Capacitor Techniques for High Accuracy Filter and ADC Design has been demonstrated in practice with the design of CMOS SC bandpass filters and algorithmic ADC stages

Feedback Amplifiers Gaetano Palumbo, Salvatore Pennisi, 2007-05-08 This comprehensive book deals with feedback and feedback amplifiers presenting original material on the topic of feedback circuits After describing the fundamental properties of feedback the book illustrates techniques of analysis for greater insight into feedback amplifiers and design strategies to optimise their performance

Low-Voltage Low-Power Analog Integrated Circuits Wouter A. Serdijn, 2012-12-06 Low

Voltage Low Power Analog Integrated Circuits brings together in one place important contributions and state of the art research results in this rapidly advancing area Low Voltage Low Power Analog Integrated Circuits serves as an excellent reference providing insight into some of the most important issues in the field

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

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