



Yelin Wang
Hao Cai

Ultra-Low-Power CMOS Sigma-Delta Modulator for Cardiac Pacemakers

Top-Down Design Guide



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Ultra Low Power Cmos Sigma Delta Modulator For Cardiac Pacemakers Top Down Design Guide

Fernando Medeiro,Belén Pérez-Verdú,Angel Rodríguez-Vázquez



Ultra Low Power Cmos Sigma Delta Modulator For Cardiac Pacemakers Top Down Design Guide:

Ultra-Low-Power CMOS Sigma-Delta Modulator for Cardiac Pacemakers Yelin Wang, Hao Cai, 2014-07-01 For modern biomedical implantable devices lowering power consumption as much as possible is critical to extend the active time of the battery which is not feasible to be replaced frequently Introduced in the 1950s implantable cardiac pacemakers are used to treat bradyarrhythmia For a pacemaker long over 15 years service time is the most critical design objective Analog to digital converter ADC is an indispensable module in any pacemaker The book presents the design of a low power CMOS Sigma Delta modulator which can be employed for implementation of the ADC The entire design process from system definition and synthesis to transistor level circuit implementation is elaborated Important design considerations are also discussed in each design phase This book can serve as a quick and detailed top down design guide for the readers who are interested in the area as well as for the university students who are in the early stage of their research **Sigma-Delta Converters:**

Practical Design Guide Jose M. de la Rosa, 2018-11-05 Thoroughly revised and expanded to help readers systematically increase their knowledge and insight about Sigma Delta Modulators Sigma Delta Modulators SDMs have become one of the best choices for the implementation of analog digital interfaces of electronic systems integrated in CMOS technologies Compared to other kinds of Analog to Digital Converters ADCs Ms cover one of the widest conversion regions of the resolution versus bandwidth plane being the most efficient solution to digitize signals in an increasingly number of applications which span from high resolution low bandwidth digital audio sensor interfaces and instrumentation to ultra low power biomedical systems and medium resolution broadband wireless communications Following the spirit of its first edition Sigma Delta Converters Practical Design Guide 2nd Edition takes a comprehensive look at SDMs their diverse types of architectures circuit techniques analysis synthesis methods and CAD tools as well as their practical design considerations It compiles and updates the current research reported on the topic and explains the multiple trade offs involved in the whole design flow of Sigma Delta Modulators from specifications to chip implementation and characterization The book follows a top down approach in order to provide readers with the necessary understanding about recent advances trends and challenges in state of the art Ms It makes more emphasis on two key points which were not treated so deeply in the first edition It includes a more detailed explanation of Ms implemented using Continuous Time CT circuits going from system level synthesis to practical circuit limitations It provides more practical case studies and applications as well as a deeper description of the synthesis methodologies and CAD tools employed in the design of converters Sigma Delta Converters Practical Design Guide 2nd Edition serves as an excellent textbook for undergraduate and graduate students in electrical engineering as well as design engineers working on SD data converters who are looking for a uniform and self contained reference in this hot topic With this goal in mind and based on the feedback received from readers the contents have been revised and structured to make this new edition a unique monograph written in a didactical pedagogical and intuitive style

CMOS Sigma-Delta Converters Jose M. de la Rosa, Rocio del Rio, 2013-03-13 A comprehensive overview of Sigma Delta Analog to Digital Converters ADCs and a practical guide to their design in nano scale CMOS for optimal performance This book presents a systematic and comprehensive compilation of sigma delta converter operating principles the new advances in architectures and circuits design methodologies and practical considerations going from system level specifications to silicon integration packaging and measurements with emphasis on nanometer CMOS implementation The book emphasizes practical design issues from high level behavioural modelling in MATLAB SIMULINK to circuit level implementation in Cadence Design FrameWork II As well as being a comprehensive reference to the theory the book is also unique in that it gives special importance on practical issues giving a detailed description of the different steps that constitute the whole design flow of sigma delta ADCs The book begins with an introductory survey of sigma delta modulators their fundamentals architectures and synthesis methods covered in Chapter 1 In Chapter 2 the effect of main circuit error mechanisms is analysed providing the necessary understanding of the main practical issues affecting the performance of sigma delta modulators The knowledge derived from the first two chapters is presented in the book as an essential part of the systematic top down bottom up synthesis methodology of sigma delta modulators described in Chapter 3 where a time domain behavioural simulator named SIMSIDES is described and applied to the high level design and verification of sigma delta ADCs Chapter 4 moves farther down from system level to the circuit and physical level providing a number of design recommendations and practical recipes to complete the design flow of sigma delta modulators To conclude the book Chapter 5 gives an overview of the state of the art sigma delta ADCs which are exhaustively analysed in order to extract practical design guidelines and to identify the incoming trends design challenges as well as practical solutions proposed by cutting edge designs Offers a complete survey of sigma delta modulator architectures from fundamentals to state of the art topologies considering both switched capacitor and continuous time circuit implementations Gives a systematic analysis and practical design guide of sigma delta modulators from a top down bottom up perspective including mathematical models and analytical procedures behavioural modeling in MATLAB SIMULINK macromodeling and circuit level implementation in Cadence Design FrameWork II chip prototyping and experimental characterization Systematic compilation of cutting edge sigma delta modulators Complete description of SIMSIDES a time domain behavioural simulator implemented in MATLAB SIMULINK Plenty of examples case studies and simulation test benches covering the different stages of the design flow of sigma delta modulators A number of electronic resources including SIMSIDES the statistical data used in the state of the art survey as well as many design examples and test benches are hosted on a companion website Essential reading for Researchers and electronics engineering practitioners interested in the design of high performance data converters integrated in nanometer CMOS technologies mixed signal designers [Design of Low-Voltage Low-Power CMOS Delta-Sigma A/D Converters](#) Vincenzo Peluso, Michiel Steyaert, Willy Sansen, 1999-02-28 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. **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 I 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 unexperienced designers who have been committed to developing a I converter mainly because there is a lack of methodology. In our view a clear methodology is necessary in I modulator design because all related tasks are rather hard.

Low Power Analog CMOS for Cardiac Pacemakers Fernando Silveira, Denis Flandre, 2004-01-31 Power reduction is a central priority in battery powered medical implantable devices particularly pacemakers to either increase battery lifetime or decrease size using a smaller battery. *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. At the technology level we analyze the impact that the application of the fully depleted silicon on insulator (FD SOI) technology has on this kind of analog circuits. The basic building block levels as well as the system level pacemaker sense channel are considered. Concerning the design technique we apply a methodology based on the transconductance to current ratio that exploits all regions of inversion of the MOS transistor. Various performance aspects of analog building blocks are modeled and a power optimization synthesis of OTAs for a given total settling time including the slewing and linear regions is proposed. At the circuit level we present a new design approach of a class AB output stage suitable for micropower application. In our design approach the usual advantages of the application of a class AB output stage are enhanced by the application of a transconductance multiplication effect. These techniques are tested in experimental prototypes of amplifiers and complete pacemaker sense channel implementations in SOI and standard bulk CMOS technologies. An ultra low consumption of 110 nA (0.3 W) is achieved in a FD SOI sense channel implementation. Though primarily addressed to the pacemaker system the techniques proposed are shown to have application in other contexts where power reduction is a main concern.

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

Low-Power Low-Voltage Sigma-Delta Modulators in Nanometer CMOS Libin Yao, Michiel Steyaert, Willy M Sansen, 2006-07-09 Low Power Low Voltage Sigma Delta Modulators in Nanometer CMOS addresses the low power low voltage Sigma Delta ADC design in nanometer CMOS technologies at both the circuit level and the system level The low power low voltage Sigma Delta modulator design at the circuit level is introduced A design example is presented in this book This design is the first published Sigma Delta design in a 90 nm CMOS technology and reaches a very high figure of merit At the system level a novel systematic study on the full feedforward Sigma Delta topology is presented in this book As a design example a fourth order single loop full feedforward Sigma Delta modulator design in a 130 nm pure digital CMOS technology is presented This design is the first design using the full feedforward Sigma Delta topology and reaches the highest conversion speed among all the 1 V Sigma Delta modulators to date

Top-Down Design of High-Performance Sigma-Delta Modulators Fernando Medeiro, Belén Pérez-Verdú, Angel Rodríguez-Vázquez, 2013-01-11 The interest for I 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 I 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 I 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 Δ converter mainly because there is a lack of methodology In our view a clear methodology is necessary in Δ modulator design because all related tasks are rather hard

CMOS Cascade Sigma-Delta Modulators for Sensors and Telecom Rocío Río Fernández, Fernando Medeiro

Hidalgo, Belén Pérez Verdú, José Manuel Rosa Utrera, Ángel Rodríguez-Vázquez, 2006-09-03 Institutional book not really for bookstore catalogue The book contains valuable information structured to provide insight on how to design SC sigma delta modulators It presents architectures circuits models methods and practical considerations for the design of high performance low pass switched capacitor SC sigma delta A/D interfaces for mixed signal CMOS ASICs The main focus of the book is on cascade architectures It differs from other books in the complete in depth coverage of SC circuit errors **Design**

Techniques for Ultra Low Voltage CMOS Continuous-time Filters and Continuous-time Sigma-delta Modulators

Huanzhang Huang, 2001 The proposed technique does not require any peak detectors which are difficult to implement at low voltage A direct digital background tuning technique for the notch frequency of continuous time sigma delta modulator is proposed to solve the large SNR loss problem caused by the deviation of the actual notch frequency from the desired value due to process and temperature changes To demonstrate the proposed low voltage design technique the frequency and Q tuning technique and the notch frequency tuning technique a 1V continuous time filter and a 1.2V continuous time band pass sigma delta modulator prototypes are designed fabricated and tested For a 5 kHz sine wave input signal the filter achieves a THD of 60.2 dB for a peak to peak output voltage of 600 mV The measured power consumption for the filter alone consumes about 0.52mW for a supply voltage of 0.5 V The measured DR for the 1.2V modulator is about 40dB 6.5bit and the peak SNR is 44dB 7bit The power consumption is 2.1mW Design of Low Power and Low Area Passive Sigma Delta Modulators for Audio Applications

David Fouto, Nuno Paulino, 2017-05-28 This book presents the study design modulation optimization and implementation of low power passive DTMs for use in audio applications The high gain and bandwidth amplifier normally used for integration in modulation is replaced by passive switched capacitor branches working under the Ultra Incomplete Settling UIS condition leading to a reduction of the consumed power The authors describe a design process that uses high level models and an optimization process based in genetic algorithms to achieve the desired performance **Systematic**

Design of CMOS Switched-Current Bandpass Sigma-Delta Modulators for Digital Communication Chips José M. de la Rosa, Belén Pérez-Verdú, Ángel Rodríguez-Vázquez, 2002-03-31 This very detailed book discusses architectures circuits and procedures for the optimum design of bandpass sigma delta A/D interfaces for mixed signal chips in standard CMOS technologies It provides uniquely in depth coverage of switched current errors which supports the design of high performance SI chips *Low-voltage Low-power CMOS Sigma-delta Modulators for High-resolution A/D Conversion*

Hyunsik Park, 2008 *Delta-Sigma Data Converters* Steven R. Norsworthy, Richard Schreier, Gabor C. Temes, 1996-10-28 This comprehensive guide offers a detailed treatment of the analysis design simulation and testing of the full range of today's leading delta sigma data converters Written by professionals experienced in all practical aspects of delta sigma modulator design Delta Sigma Data Converters provides comprehensive coverage of low and high order single bit bandpass continuous time multi stage modulators as well as advanced topics including idle channel tones stability decimation and interpolation filter design and simulation

Design Techniques for Mash Continuous-Time Delta-Sigma Modulators Qiyuan Liu, Alexander Edward, Carlos Briseno-Vidrios, Jose Silva-Martinez, 2018-03-27 This book describes a circuit architecture for converting real analog signals into a digital format suitable for digital signal processors This architecture referred to as multi stage noise shaping MASH Continuous Time Sigma Delta Modulators CT M has the potential to provide better digital data quality and achieve better data rate conversion with lower power consumption The authors not only cover MASH continuous time sigma delta modulator fundamentals but also provide a literature review that will allow students professors and professionals to catch up on the latest developments in related technology

Design Trade-off of Low Power Continuous-time [Sigma Delta] Modulators for A/D Conversions Tongyu Song, 2007 The research investigates several critical design issues of continuous time CT Sigma Delta modulators The first is to investigate the sensitivity of CT Sigma Delta modulators to high frequency clock spurs These spurs down convert the high frequency quantization noise degrading the dynamic range of the modulator The second is to study the robustness of continuous time loop filters under large RC product variations Large RC variations in the CMOS process strongly degrade the performance of continuous time Sigma Delta modulators and reduce the production yield The third is to model the harmonic distortion of one bit continuous time Sigma Delta modulators due to the interaction between the first integrator and the feedback digital to analog converter DAC A closed form expression of the 3rd order harmonic distortion is derived and verified Conventional CT Sigma Delta modulators employ all active integrators each integrator needs an active amplifier The research proposes a 5th order continuous time Sigma Delta modulator with a hybrid active passive loop filter consisting of only three amplifiers The passive integrators save power and introduce no distortion The active integrators provide gain and minimize internal noise contributions A single bit switched capacitor DAC is employed as the main feedback DAC for high clock jitter immunity An additional current steering DAC stabilizes the loop with the advantage of simplicity To verify the proposed techniques a prototype continuous time Sigma Delta modulator with 2 MHz signal bandwidth is designed in a 0.25 μ m CMOS technology targeting for GPS or WCDMA applications The experimental results show that the prototype modulator achieves 68 dB dynamic range over 2 MHz bandwidth with a 150 MHz clock consuming 1.8 mA from a 1.5 V supply

Nanometer CMOS Sigma-Delta Modulators for Software Defined Radio Alonso Morgado, Rocío del Río, José M. de la Rosa, 2011-09-15 This book presents innovative solutions for the implementation of Sigma Delta Modulation SDM based Analog to Digital

Conversion ADC required for the next generation of wireless hand held terminals These devices will be based on the so called multi standard transceiver chipsets integrated in nanometer CMOS technologies One of the most challenging and critical parts in such transceivers is the analog digital interface because of the assorted signal bandwidths and dynamic ranges that can be required to handle the A D conversion for several operation modes This book describes new adaptive and reconfigurable SDM ADC topologies circuit strategies and synthesis methods specially suited for multi standard wireless telecom systems and future Software defined radios SDRs integrated in nanoscale CMOS It is a practical book going from basic concepts to the frontiers of SDM architectures and circuit implementations which are explained in a didactical and systematic way It gives a comprehensive overview of the state of the art performance challenges and practical solutions providing the necessary insight to implement successful design through an efficient design and synthesis methodology Readers will learn a number of practical skills from system level design to experimental measurements and testing The Design of Low Voltage, Low Power Delta Sigma Modulator for Pacemakers Che-Wei Wu, 2011 **Continuous-Time Sigma-Delta A/D Conversion** Friedel Gerfers, Maurits Ortmanns, 2006-02-27 Sigma delta A D converters are a key building block in wireless and multimedia applications This comprehensive book deals with all relevant aspects arising during the analysis design and simulation of the now widespread continuous time implementations of sigma delta modulators The results of several years of research by the authors in the field of CT sigma delta modulators are covered including the analysis and modeling of different CT modulator architectures CT DT loop filter synthesis a detailed error analysis of all components and possible compensation correction schemes for the non ideal behavior in CT sigma delta modulators Guidance for obtaining low power consumption and several practical implementations are also presented It is shown that all the proposed new theories architectures and possible correction techniques have been confirmed by measurements on discrete or integrated circuits Quantitative results are also provided thus enabling prediction of the resulting accuracy

Ultra Low Power Cmos Sigma Delta Modulator For Cardiac Pacemakers Top Down Design Guide Book Review: Unveiling the Magic of Language

In an electronic era where connections and knowledge reign supreme, the enchanting power of language has are more apparent than ever. Its capability to stir emotions, provoke thought, and instigate transformation is truly remarkable. This extraordinary book, aptly titled "**Ultra Low Power Cmos Sigma Delta Modulator For Cardiac Pacemakers Top Down Design Guide**," written by a very acclaimed author, immerses readers in a captivating exploration of the significance of language and its profound affect our existence. Throughout this critique, we shall delve to the book is central themes, evaluate its unique writing style, and assess its overall influence on its readership.

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