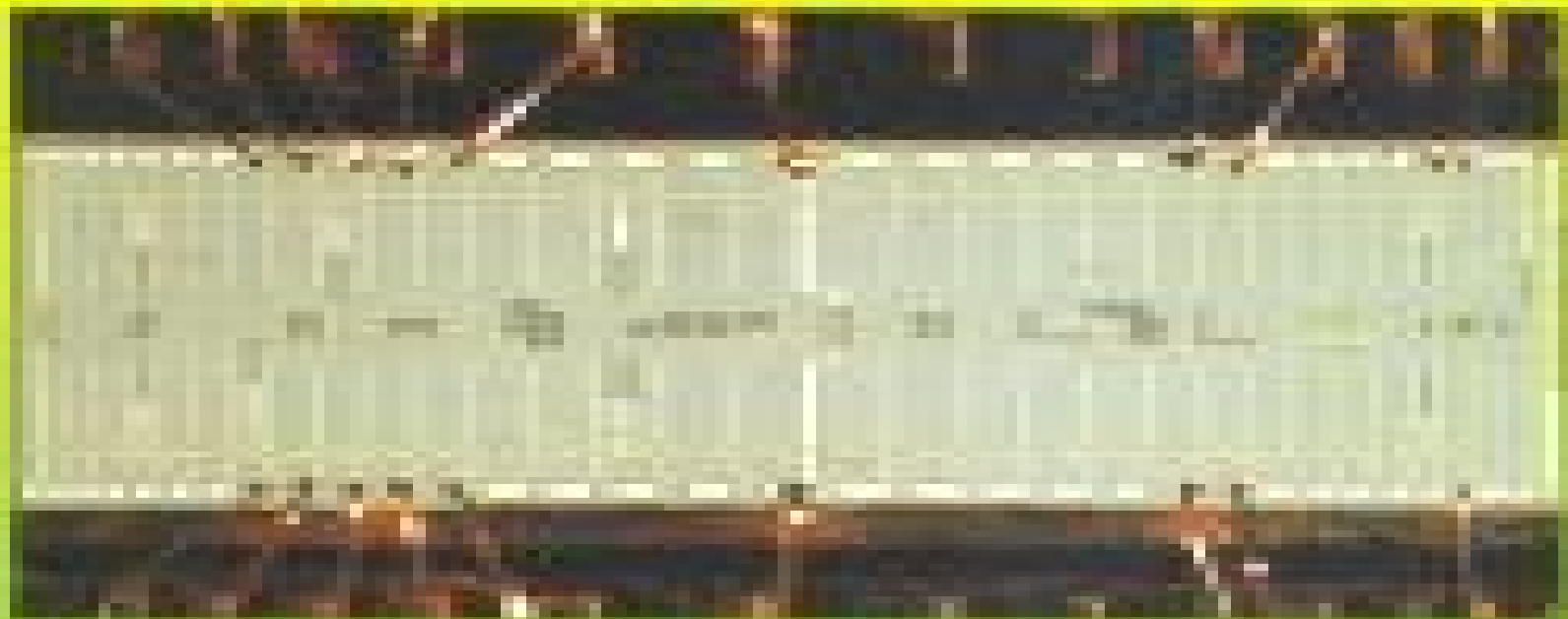


# The Pseudojunction Effect in Silicon, its Consequences and Applications for Integrated Circuits and Sensors



Fabrizio Bracci

# Piezojunction Effect In Silicon Integrated Circuits And Sensors

**Fabiano Fruett, Gerard C.M. Meijer**



## **Piezojunction Effect In Silicon Integrated Circuits And Sensors:**

**The Piezojunction Effect in Silicon Integrated Circuits and Sensors** Fabiano Fruett, Gerard C.M. Meijer, 2006-04-18

Mechanical stress affects the magnitude of base emitter voltages of forward biased bipolar transistors. This phenomenon is called the piezojunction effect. The piezojunction effect is the main cause of inaccuracy and drift in integrated temperature sensors and bandgap voltage references. The aim of *The Piezojunction Effect in Silicon Integrated Circuits and Sensors* is twofold. Firstly to describe techniques that can reduce the mechanical stress induced inaccuracy and long term instability. Secondly to show that the piezojunction effect can be applied for new types of mechanical sensor structures. During IC fabrication and packaging thermo mechanical stress is induced when the packaged chips cool down to the temperature of application. The piezojunction effect is caused by a stress induced change in the conductivity of the minority charge carriers while the piezoresistive effect is caused by a similar effect for the majority charge carriers. To characterise the anisotropic piezojunction effect the authors performed systematic investigations over wide ranges of mechanical stress and temperature. The experiments have been performed for various crystal and stress orientations. The experimental results have been used to extract the first and second order piezojunction FOPJ and SOPJ coefficients for bipolar transistors. It is shown how the knowledge of the piezojunction and piezoresistive coefficients can be used to minimize the undesirable mechanical stress effects on the electrical characteristics of transistors and resistors respectively. Devices with lower mechanical stress sensitivity can be found by comparing their piezo coefficients. The layout of the device can also be optimized to reduce the mechanical stress sensitivity. As a next step it is shown how the knowledge of the piezo effects on device level can be used to predict and to reduce their negative influence on circuit level. This is demonstrated for a number of important basic circuits including translinear circuits, temperature transducers and bandgap references. Finally it is shown how the piezojunction effect can be used to fabricate stress sensing elements. It appears that in comparison with resistive stress sensing elements the piezojunction sensors have the advantage of a smaller size and very low power dissipation.

*The Piezojunction Effect in Silicon, Its Consequences and Applications for Integrated Circuits and Sensors* F. Fruett, 2001-01-01

*Smart Sensor Systems* Gerard Meijer, Kofi Makinwa, Michiel Pertijs, 2014-04-02

With contributions from an internationally renowned group of experts, this book uses a multidisciplinary approach to review recent developments in the field of smart sensor systems covering important system and design aspects. It examines topics over the whole range of sensor technology from the theory and constraints of basic elements (physics and electronics) up to the level of application orientated issues. Developed as a complementary volume to *Smart Sensor Systems* Wiley 2008 which introduces the basics of smart sensor systems, this volume focuses on emerging sensing technologies and applications including state-of-the-art techniques for designing smart sensors and smart sensor systems including measurement techniques at system level such as dynamic error correction, calibration, self calibration and trimming. Circuit design for sensor systems such as the design of precision instrumentation.

amplifiers Impedance sensors and the associated measurement techniques and electronics that measure electrical characteristics to derive physical and biomedical parameters such as blood viscosity or growth of micro organisms Complete sensor systems on a chip such as CMOS optical imagers and microarrays for DNA detection and the associated circuit and micro fabrication techniques Vibratory gyroscopes and the associated electronics employing mechanical and electrical signal amplification to enable low power angular rate sensing Implantable smart sensors for neural interfacing in bio medical applications Smart combinations of energy harvesters and energy storage devices for autonomous wireless sensors Smart Sensor Systems Emerging Technologies and Applications will greatly benefit final year undergraduate and postgraduate students in the areas of electrical mechanical and chemical engineering and physics Professional engineers and researchers in the microelectronics industry including microsystem developers will also find this a thorough and useful volume Smart Sensors and MEMS S Nihitjanov,A. Luque,2018-02-27 Smart Sensors and MEMS Intelligent Devices and Microsystems for Industrial Applications Second Edition highlights new important developments in the field including the latest on magnetic sensors temperature sensors and microreaction chambers The book outlines the industrial applications for smart sensors covering direct interface circuits for sensors capacitive sensors for displacement measurement in the sub nanometer range integrated inductive displacement sensors for harsh industrial environments advanced silicon radiation detectors in the vacuum ultraviolet VUV and extreme ultraviolet EUV spectral range among other topics New sections include discussions on magnetic and temperature sensors and the industrial applications of smart micro electro mechanical systems MEMS The book is an invaluable reference for academics materials scientists and electrical engineers working in the microelectronics sensors and micromechanics industry In addition engineers looking for industrial sensing monitoring and automation solutions will find this a comprehensive source of information Contains new chapters that address key applications such as magnetic sensors microreaction chambers and temperature sensors Provides an in depth information on a wide array of industrial applications for smart sensors and smart MEMS Presents the only book to discuss both smart sensors and MEMS for industrial applications *Energy-Efficient Smart Temperature Sensors in CMOS Technology* Kamran Souri,Kofi A.A. Makinwa,2017-10-05 This book describes the design and implementation of energy efficient smart digital output temperature sensors in CMOS technology To accomplish this a new readout topology namely the zoom ADC is presented It combines a coarse SAR ADC with a fine Sigma Delta SD ADC The digital result obtained from the coarse ADC is used to set the reference levels of the SD ADC thereby zooming its full scale range into a small region around the input signal This technique considerably reduces the SD ADC s full scale range and notably relaxes the number of clock cycles needed for a given resolution as well as the DC gain and swing of the loop filter Both conversion time and power efficiency can be improved which results in a substantial improvement in energy efficiency Two BJT based sensor prototypes based on 1st order and 2nd order zoom ADCs are presented They both achieve inaccuracies of less than 0.2 °C over the military temperature range -55 °C

to 125 °C A prototype capable of sensing temperatures up to 200 °C is also presented As an alternative to BJT's sensors based on dynamic threshold MOSTs DTMOSTs are also presented It is shown that DTMOSTs are capable of achieving low inaccuracy 0.4 °C over the military temperature range as well as sub 1V operation making them well suited for use in modern CMOS processes

**Precision Temperature Sensors in CMOS Technology** Micheal A.P. Pertijs, Johan Huijsing, 2006-12-06 The low cost and direct digital output of CMOS smart temperature sensors are important advantages compared to conventional temperature sensors This book addresses the main problem that nevertheless prevents widespread application of CMOS smart temperature sensors their relatively poor absolute accuracy Several new techniques are introduced to improve this accuracy The effectiveness of these techniques is demonstrated using three prototypes The final prototype achieves an inaccuracy of 0.1 °C over the military temperature range which is a significant improvement in the state of the art Since smart temperature sensors have been the subject of academic and industrial research for more than two decades an overview of existing knowledge and techniques is also provided throughout the book In this introductory chapter the motivation and objectives of this work are described This is followed by a review of the basic operating principles of CMOS smart temperature sensors and a brief overview of previous work The challenges are then described that need to be met in order to improve the accuracy of CMOS smart temperature sensors while maintaining their cost advantage Finally the structure of the rest of the book is introduced

**Microelectronics Technology and Devices, SBMICRO 2004** Edval J. P. Santos, Renato P. Ribas, 2004

**CMOS Circuit Design for RF Sensors** Gunnar Gudnason, Erik Bruun, 2006-04-18 CMOS Circuit Design for RF Sensors is about CMOS circuit design for sensor and actuators to be used in wireless RF systems The main application is implantable transducers for biomedical purposes such as sensing of nerve signals and electrical stimulation of nerves Special focus is put on the power and data link in a wireless system with transducers which are powered via the RF link Novel principles and methods are presented for the regulation of power to the sensors and for the distribution of data and power in an implanted transducer system One of the main problems in such systems is the transmission of power via an RF link This problem is analyzed in detail and solutions incorporating an RF magnetic link to the transducers are identified The theoretical results are supported by experiments from CMOS chips including a system chip for functional electrical stimulation FES

**CMOS Integrated Analog-to-Digital and Digital-to-Analog Converters** Rudy J. van de Plassche, 2013-04-17 CMOS Integrated Analog to Digital and Digital to Analog Converters describes in depth converter specifications like Effective Number of Bits ENOB Spurious Free Dynamic Range SFDR Integral Non Linearity INL Differential Non Linearity DNL and sampling clock jitter requirements Relations between these specifications and practical issues like matching of components and offset parameters of differential pairs are derived CMOS Integrated Analog to Digital and Digital to Analog Converters describes the requirements of input and signal reconstruction filtering in case a converter is applied into a signal processing system CMOS Integrated Analog to Digital and Digital to Analog Converters describes design

details of high speed A/D and D/A converters high resolution A/D and D/A converters sample and hold amplifiers voltage and current references noise shaping converters and sigma delta converters technology parameters and matching performance comparators and limitations of comparators and finally testing of converters      **High Data Rate Transmitter Circuits** C.J. de Ranter, Michiel Steyaert, 2006-04-18 High Data Rate Transmitter Circuits is a practical guide and introduction to the design of key RF building blocks used in high data rate transmitters The emphasis lies on CMOS circuit techniques applicable to oscillators and upconvertors Furthermore a method for RF specific design automation is exemplified by the CYCLONE tool for automated LC VCO synthesis Written in an easily accessible manner High Data Rate Transmitter Circuits is essential reading for both students and practicing engineers interested in analog RF design and RF specific design automation The book has been praised for its pleasant and light style of writing without losing detail on the technical side

**Microelectronics Technology and Devices, SBMICRO 2002** Electrochemical Society. Electronics Division, 2002

Mixed-Signal Layout Generation Concepts Chieh Lin, Arthur H.M. van Roermund, Domine Leenaerts, 2005-12-15 This title covers important physical design issues that exist in contemporary analogue and mixed signal design flows The authors bring together many principles and techniques required to successfully develop and implement layout generation tools to accommodate many mixed signal layout generation needs      *Circuit Design for Wireless Communications* Kong-Pang Pun, José Epifanio da Franca, Carlos Azeredo-Leme, 2013-03-09 Circuit Design for Wireless Communications Improved Techniques for Image Rejection in Wideband Quadrature Receivers is the first book focusing on the subject of image rejection in wireless receiver design which has never been so important as high level of integration is highly demanded in the current and next generation mobile terminals In this book the image rejection problems in various receiver architectures which are suitable for high level of integration including image reject direct conversion and low IF architectures are studied The fundamental source of the limitation of the image rejection in these receivers is the imbalance between their in phase I and quadrature Q channels which becomes more problematic when the receivers are of wideband Besides traditional methods this book provides novel solutions to the problem which falls into two broad types The first type refers to new circuits that produce less I/Q imbalance This includes high performance switched capacitor Hilbert transformers and precise quadrature sampling circuits The second type is to compensate the I/Q imbalance which is possibly frequency dependent in digital domain by calibration or signal processing techniques Design examples have been included Circuit Design for Wireless Communications Improved Techniques for Image Rejection in Wideband Quadrature Receivers serves as a very useful reference for wireless design engineers who want to improve the image rejection of their wireless receivers and researchers and students who are interested in this subject      Modular Low-Power, High-Speed CMOS Analog-to-Digital Converter of Embedded Systems Keh-La Lin, Armin Kemna, Bedrich J. Hosticka, 2006-01-14 One of the main trends of microelectronics is toward design for integrated systems i.e. system on a chip SoC or system on silicon SoS Due to this

development design techniques for mixed signal circuits become more important than before Among other devices analog to digital and digital to analog converters are the two bridges between the analog and the digital worlds Besides low power design technique is one of the main issues for embedded systems especially for hand held applications Modular Low Power High Speed CMOS Analog to Digital Converter for Embedded Systems aims at design techniques for low power high speed analog to digital converter processed by the standard CMOS technology Additionally this book covers physical integration issues of A/D converter integrated in SoC i.e. substrate crosstalk and reference voltage network design

**Design of High-Performance CMOS Voltage-Controlled Oscillators** Liang Dai, Ramesh Harjani, 2012-12-06 Design of High Performance CMOS Voltage Controlled Oscillators presents a phase noise modeling framework for CMOS ring oscillators The analysis considers both linear and nonlinear operation It indicates that fast rail to rail switching has to be achieved to minimize phase noise Additionally in conventional design the flicker noise in the bias circuit can potentially dominate the phase noise at low offset frequencies Therefore for narrow bandwidth PLLs noise up conversion for the bias circuits should be minimized We define the effective Q factor  $Q_{eff}$  for ring oscillators and predict its increase for CMOS processes with smaller feature sizes Our phase noise analysis is validated via simulation and measurement results The digital switching noise coupled through the power supply and substrate is usually the dominant source of clock jitter Improving the supply and substrate noise immunity of a PLL is a challenging job in hostile environments such as a microprocessor chip where millions of digital gates are present

**Systematic Design of Analog IP Blocks** Jan Vandenbussche, Georges Gielen, Michiel Steyaert, 2013-03-14 Systematic Design of Analog IP Blocks introduces a design methodology that can help to bridge the productivity gap Two different types of designs depending on the design challenge have been identified commodity IP and star IP Each category requires a different approach to boost design productivity Commodity IP blocks are well suited to be automated in an analog synthesis environment and provided as soft IP The design knowledge is usually common knowledge and reuse is high accounting for the setup time needed for the analog library Star IP still changes as technology evolves and the design cost can only be reduced by following a systematic design approach supported by point tools to relieve the designer from error prone repetitive tasks allowing him/her to focus on new ideas to push the limits of the design To validate the presented methodologies three different industrial strength applications have been selected and designed accordingly

*Circuit Techniques for Low-Voltage and High-Speed A/D Converters* Mikko E. Waltari, Kari A.I. Halonen, 2005-12-30 For four decades the evolution of integrated circuits has followed Moore's law according to which the number of transistors per square millimeter of silicon doubles every 18 months At the same time transistors have become faster making possible ever increasing clock rates in digital circuits This trend seems set to continue for at least another decade without slowing down Thus in the near future the processing power of digital circuits will continue to increase at an accelerating pace For analog circuits the evolution of technology is not as beneficial Thus there is a trend to move signal processing functions from the

analog domain to the digital one which besides allowing for a higher level of accuracy provides savings in power consumption and silicon area increases robustness speeds up the design process brings flexibility and programmability and increases the possibilities for design reuse In many applications the input and output signals of the system are inherently analog preventing all digital realizations at the very least a conversion between analog and digital is needed at the interfaces Typically moving the analog digital boundary closer to the outside world increases the bit rate across it In telecommunications systems the trend to boost bit rates is based on plying widerbandwidths and a higher signal to noise ratio At the same time radio architectures in many applications are evolving toward software defined radio one of the main characteristics of which is the shifting of the anal digital boundary closer to the antenna

#### Design of Low-Voltage CMOS Switched-Opamp

Switched-Capacitor Systems Vincent S.L. Cheung,Howard Cam H. Luong,2013-03-14 In Design of Low Voltage CMOS Switched Opamp Switched Capacitor Systems the emphasis is put on the design and development of advanced switched opamp architectures and techniques for low voltage low power switched capacitor SC systems Specifically the book presents a novel multi phase switched opamp technique together with new system architectures that are critical in improving significantly the performance of switched capacitor systems at low supply voltages A generic fast settling double sampling SC biquadratic filter architecture is proposed to achieve high speed operation for SC circuits A low voltage double sampling DS finite gain compensation FGC technique is employed to realize high resolution SD modulator using only low DC gain opamps to maximize the speed and to reduce power dissipation A family of novel power efficient SC filters and SD modulators are built based on using only half delay SC integrators Single opamp based SCsystems are designed for ultra low power applications In addition on the circuit level a fast switching methodology is proposed for the design of the switchable opamps to achieve switching frequency up to 50 MHz at 1V which is improved by about ten times compared to the prior arts Finally detailed design considerations architecture choices and circuit implementation of five chip prototypes are presented to illustrate potential applications of the proposed multi phase switched opamp technique to tackle with and to achieve different stringent design corners such as high speed high integration level and ultra low power consumption at supply voltages of 1V or lower in standard CMOS processes

#### Introduction to Avionics Systems R.P.G. Collinson,2002-12-31

Evaluation copies are available Please contact textbooks wkap com Provide the course number number of students and present textbook used Introduction to Avionics Systems Second Edition explains the basic principles and underlying theory of modern avionic systems and how they are implemented with current technology for both civil and military aircraft in a clear and easy to read manner All systems are explained so that their design and performance can be understood and analysed Worked examples are included to illustrate the application of the theory and principles covered The latest developments and directions of research for future systems are included This new second edition has approximately 25% new material and takes into account the technology developments which have taken place since the first edition was published in January 1996 The book



is well illustrated with line drawings and photos with some in colour where appropriate Readership Graduates or equivalent from a range of disciplines entering the avionics and aerospace industries Engineers at all levels engaged in the design and development of avionic systems and equipment in the avionic and aerospace industries Students and post graduate students taking avionics and aeronautical engineering courses Staff in the armed services and civil airlines engaged in the support or operation of aircraft who wish to acquire a deeper understanding of the design and implementation of avionic systems and equipment

**Low-Voltage CMOS Log Companding Analog Design** Francisco Serra-Graells, Adoración Rueda, José L. Huertas, 2006-04-18 Low Voltage CMOS Log Companding Analog Design presents in detail state of the art analog circuit techniques for the very low voltage and low power design of systems on chip in CMOS technologies The proposed strategy is mainly based on two bases the Instantaneous Log Companding Theory and the MOSFET operating in the subthreshold region The former allows inner compression of the voltage dynamic range for very low voltage operation while the latter is compatible with CMOS technologies and suitable for low power circuits The required background on the specific modeling of the MOS transistor for Companding is supplied at the beginning Following this general approach a complete set of CMOS basic building blocks is proposed and analyzed for a wide variety of analog signal processing In particular the covered areas include amplification and AGC arbitrary filtering PTAT generation and pulse duration modulation PDM For each topic several case studies are considered to illustrate the design methodology Also integrated examples in 1.2  $\mu\text{m}$  and 0.35  $\mu\text{m}$  CMOS technologies are reported to verify the good agreement between design equations and experimental data The resulting analog circuit topologies exhibit very low voltage i.e. 1V and low power few tenths of  $\mu\text{A}$  capabilities Apart from these specific design examples a real industrial application in the field of hearing aids is also presented as the main demonstrator of all the proposed basic building blocks This system on chip exhibits true 1V operation high flexibility through digital programmability and very low power consumption about 300  $\mu\text{A}$  including the Class D amplifier As a result the reported ASIC can meet the specifications of a complete family of common hearing aid models In conclusion this book is addressed to both industry ASIC designers who can apply its contents to the synthesis of very low power systems on chip in standard CMOS technologies as well as to the teachers of modern circuit design in electronic engineering

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