

THE PIEZOELECTRIC EFFECT IN SILICON INTEGRATED CIRCUITS AND SENSORS

Fabiano Fruett and Gerard C.M. Meijer

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Piezojunction Effect In Silicon Integrated Circuits And Sensors

Kamran Souri, Kofi A.A. Makinwa



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, 2014-06-23

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

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