

# **HIGH-ACCURACY CMOS SMART TEMPERATURE SENSORS**

**Anton Bakker and  
Johan Huijsing**

Springer Science+Business Media, LLC

# High Accuracy Cmos Smart Temperature Sensors

**Ernst Obermeier**



## **High Accuracy Cmos Smart Temperature Sensors:**

High-Accuracy CMOS Smart Temperature Sensors Anton Bakker, Johan Huijsing, 2013-03-09 This book describes the theory and design of high accuracy CMOS smart temperature sensors The major topic of the work is the realization of a smart temperature sensor that has an accuracy that is so high that it can be applied without any form of calibration Integrated in a low cost CMOS technology this yields at the publication date of this book one of the most inexpensive intelligent general purpose temperature sensors in the world The first thermometers could only be read by the human eye The industrial revolution and the following computerization asked for more intelligent sensors which could easily communicate to digital computers This led to the development of integrated temperature sensors that combine a bipolar temperature sensor and an A to D converter on the same chip The implementation in CMOS technology reduces the processing costs to a minimum while having the best suited technology to increase the digital intelligence The accuracy of conventional CMOS smart temperature sensors is degraded by the offset of the read out electronics Calibration of these errors is quite expensive however dynamic offset cancellation techniques can reduce the offset of amplifiers by a factor 100 to 1000 and do not need trimming Chapter two gives an elaborate description of the different kinds of dynamic offset cancellation techniques Also a new technique is introduced called the nested chopper technique An implementation of a CMOS nested chopper instrumentation amplifier shows a residual offset of less than 100 nV which is the best result reported to date

**High-accuracy CMOS Smart Temperature Sensors** Anthonius Bakker, 2000      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 BJTs 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 **Proceeding of the Second International Conference on Microelectronics, Computing & Communication Systems (MCCS 2017)**

Vijay Nath, Jyotsna Kumar Mandal, 2018-07-30 The volume presents high quality papers presented at the Second International Conference on Microelectronics Computing Communication Systems MCCS 2017 The book discusses recent trends in technology and advancement in MEMS and nanoelectronics wireless communications optical communication instrumentation signal processing image processing bioengineering green energy hybrid vehicles environmental science weather forecasting cloud computing renewable energy RFID CMOS sensors actuators transducers telemetry systems embedded systems and sensor network applications It includes original papers based on original theoretical practical experimental simulations development application measurement and testing The applications and solutions discussed in the book will serve as a good reference material for future works *Transducers '01 Eurosensors XV* Ernst Obermeier, 2016-05-12 The Conference is the premier international meeting for the presentation of original work addressing all aspects of the theory design fabrication assembly packaging testing and application of solid state sensors actuators MEMS and microsystems [Advanced Materials and Technologies for Micro/Nano-Devices, Sensors and Actuators](#) Evgeni Gusev, Eric Garfunkel, Arthur Dideikin, 2010-03-15 A NATO Advanced Research Workshop ARW entitled Advanced Materials and Technologies for Micro Nano Devices Sensors and Actuators was held in St Petersburg Russia from June 29 to July 2 2009 The main goal of the Workshop was to examine at a fundamental level the very complex scientific issues that pertain to the use of micro and nano electromechanical systems MEMS and NEMS devices and technologies in next generation commercial and defense related applications Micro and nano electromechanical systems represent rather broad and diverse technological areas such as optical systems micromirrors waveguides optical sensors integrated subsystems life sciences and lab equipment micropumps membranes lab on chip membranes microfluidics sensors bio sensors chemical sensors gas phase sensors sensors integrated with electronics and RF applications for signal transmission variable capacitors tunable filters and antennas switches resonators From a scientific viewpoint this is a very multi disciplinary field including micro and nano mechanics such as stresses in structural materials

electronic effects e.g. charge transfer, general electrostatics, materials science, surface chemistry, interface science, nano tribology and optics. It is obvious that in order to overcome the problems surrounding next generation MEMS/NEMS devices and applications, it is necessary to tackle them from different angles: theoreticians need to speak with mechanical engineers and device engineers, and modelers need to listen to surface physicists. It was therefore one of the main objectives of the workshop to bring together a multidisciplinary team of distinguished researchers.

**Proceeding of International Conference on Intelligent Communication, Control and Devices** Rajesh Singh, Sushabhan Choudhury, 2016-09-17. The book presents high quality research papers presented at the first international conference ICICCD 2016 organised by the Department of Electronics Instrumentation and Control Engineering of University of Petroleum and Energy Studies Dehradun on 2nd and 3rd April 2016. The book is broadly divided into three sections: Intelligent Communication, Intelligent Control, and Intelligent Devices. The areas covered under these sections are: wireless communication and radio technologies, optical communication, communication hardware, evolution of machine-to-machine communication networks, routing techniques, network analytics, network applications and services, satellite and space communications technologies, for e-communication, wireless Ad Hoc and sensor networks, communications and information security, signal processing for communications, communication software, microwave informatics, robotics and automation, optimization techniques and algorithms, intelligent transport, mechatronics, system guidance and navigation, algorithms, linear/non-linear control, home automation, sensors, smart cities, control systems, high performance computing, cognition, control, adaptive control, distributed control, prediction models, hybrid control system, control applications, power system, manufacturing, agriculture, cyber physical system, network control system, genetic control, based wearable devices, nano devices, MEMS, bio-inspired computing, embedded and real time software, VLSI and embedded systems, FPGA, digital system and logic design, image and video processing, machine vision, medical imaging, and reconfigurable computing systems.

**CMOS - MEMS** Henry Baltes, Oliver Brand, Gary K. Fedder, Christofer Hierold, Jan G. Korvink, Osamu Tabata, 2013-03-26. This edition of CMOS MEMS was originally published in the successful series Advanced Micro/Nanosystems. Here the combination of the globally established billion-dollar chip mass fabrication technology CMOS with the fascinating and commercially promising new world of MEMS is covered from all angles. The book introduces readers to this field and takes them from fabrication technologies and material characterization aspects to the actual applications of CMOS MEMS: a wide range of miniaturized physical, chemical, and biological sensors and RF systems. Vital knowledge on circuit and system integration issues concludes this in-depth treatise illustrating the advantages of combining CMOS and MEMS in the first place rather than having a hybrid solution.

**Sensor Technology Handbook** Jon S. Wilson, 2005. Sensor fundamentals, Application considerations, Measurement issues and criteria, Sensor signal conditioning, Acceleration, shock and vibration sensors, Biosensors, Chemical sensors, Capacitive and inductive displacement sensors, Electromagnetism in sensing, Flow and level sensors, Force, load and weight sensors, Humidity sensors, Machinery vibration monitoring sensors, Optical and

radiation sensors Position and motion sensors Pressure sensors Sensors for mechanical shock Test and measurement microphones Strain gages Temperature sensors Nanotechnology enabled sensors Wireless sensor networks principles and applications

**Sensors And Microsystems - Proceedings Of The 6th Italian Conference** Arnaldo D'amico, Paolo Dario, Corrado Di Natale, 2001-12-28 This volume presents current research and development in the fields of sensors and microsystems Many aspects of disciplines related to sensors and microsystems are covered ranging from materials science to complete applications and multifunctional systems The variety of the topics and the quality of the papers offer readers an insight into the research status in Italy The book contains selected contributions from 37 institutions in Italy both academic institutions and public private research institutions

**Selected Topics in Power, RF, and Mixed-Signal ICs** Yan Lu, Chi-Seng Lam, 2022-09-01 Driven by advanced CMOS technology power management units RF transceivers and sensors analog and mixed signal circuits can now be fully integrated with VLSI digital systems for applications ranging from mobile internet of things IoT wearable and implantable medical devices Evidently the circuit and system level innovations have pushed the device performance boundaries to become orders of magnitude higher whilst keeping the same or even lower power consumption Selected Topic in Power RF and Mixed Signal ICs provides a practical overview and state of the art advancements on several selected topics in the areas of power RF and mixed signal integrated circuits and systems Topics covered in the book include Very High Frequency DC DC Switching Converters Analog and Digital Low Dropout Regulators Analog and Digital Sub Sampling Frequency Synthesizers Hybrid ADC Architecture with Digital Assisted Techniques CMOS Image Sensors and Their Biomedical Applications CMOS Temperature Sensors CMOS Millimeter Wave Power Amplifiers Zigbee BLE Transmitter for IoT Applications

Process Analysis, Design, and Intensification in Microfluidics and Chemical Engineering Santana, Harrson Silva, Lameu da Silva Jr, João, Taranto, Osvaldir Pereira, 2019-01-18 Microfluidics represent great potential for chemical processes design development optimization and chemical engineering bolsters the project design of industrial processes often found in large chemical plants Together microfluidics and chemical engineering can lead to a more complete and comprehensive process Process Analysis Design and Intensification in Microfluidics and Chemical Engineering provides emerging research exploring the theoretical and practical aspects of microfluidics and its application in chemical engineering with the intention of building pathways for new processes and product developments in industrial areas Featuring coverage on a broad range of topics such as design techniques hydrodynamics and numerical modelling this book is ideally designed for engineers chemists microfluidics and chemical engineering companies academicians researchers and students

**Precision Instrumentation Amplifiers and Read-Out Integrated Circuits** Rong Wu, Johan H. Huijsing, Kofi A Makinwa, 2012-07-25 This book presents innovative solutions in the design of precision instrumentation amplifier and read out ICs which can be used to boost millivolt level signals transmitted by modern sensors to levels compatible with the input ranges of typical Analog to Digital Converters ADCs The discussion includes the theory design and

realization of interface electronics for bridge transducers and thermocouples It describes the use of power efficient techniques to mitigate low frequency errors resulting in interface electronics with high accuracy low noise and low drift Since this book is mainly about techniques for eliminating low frequency errors it describes the nature of these errors and the associated dynamic offset cancellation techniques used to mitigate them

**Dynamic Offset Compensated CMOS Amplifiers** Frerik Witte,Kofi Makinwa,Johan Huijsing,2009-06-29 Dynamic Offset Compensated CMOS Amplifiers describes the theory design and realization of dynamic offset compensated CMOS amplifiers It focuses on the design of general purpose wide band operational amplifiers and instrumentation amplifiers Two offset compensation techniques are described auto zeroing and chopping Several topologies are discussed with which these techniques can be used in the design of wide band dynamic offset compensated amplifiers Four implementations are discussed in detail two low offset wide band operational amplifiers a low offset instrumentation amplifier and a low offset current sense amplifier which can sense the current drawn from supply voltages up to 28V

**Sensor Technology 2001** Miko Elwenspoek,2011-06-27 Proceedings of the Sensor Technology Conference 2001 Enschede The Netherlands 14 15 May 2001 *Proceedings of the 6th Italian Conference* Corrado Di Natale,Arnaldo D'Amico,Paolo Dario,2002 Presents current research and development in the fields of sensors and microsystems

**Stochastic Process Variation in Deep-Submicron CMOS** Amir Zjajo,2013-11-19 One of the most notable features of nanometer scale CMOS technology is the increasing magnitude of variability of the key device parameters affecting performance of integrated circuits The growth of variability can be attributed to multiple factors including the difficulty of manufacturing control the emergence of new systematic variation generating mechanisms and most importantly the increase in atomic scale randomness where device operation must be described as a stochastic process In addition to wide sense stationary stochastic device variability and temperature variation existence of non stationary stochastic electrical noise associated with fundamental processes in integrated circuit devices represents an elementary limit on the performance of electronic circuits In an attempt to address these issues Stochastic Process Variation in Deep Submicron CMOS Circuits and Algorithms offers unique combination of mathematical treatment of random process variation electrical noise and temperature and necessary circuit realizations for on chip monitoring and performance calibration The associated problems are addressed at various abstraction levels i e circuit level architecture level and system level It therefore provides a broad view on the various solutions that have to be used and their possible combination in very effective complementary techniques for both analog mixed signal and digital circuits The feasibility of the described algorithms and built in circuitry has been verified by measurements from the silicon prototypes fabricated in standard 90 nm and 65 nm CMOS technology

**Micromachining Techniques for Fabrication of Micro and Nano Structures** Mojtaba Kahrizi,2012-02-03 Micromachining is used to fabricate three dimensional microstructures and it is the foundation of a technology called Micro Electro Mechanical Systems MEMS Bulk micromachining and surface micromachining are two major categories among

others in this field This book presents advances in micromachining technology For this we have gathered review articles related to various techniques and methods of micro nano fabrications like focused ion beams laser ablation and several other specialized techniques from esteemed researchers and scientists around the world Each chapter gives a complete description of a specific micromachining method design associate analytical works experimental set up and the final fabricated devices followed by many references related to this field of research available in other literature Due to the multidisciplinary nature of this technology the collection of articles presented here can be used by scientists and researchers in the disciplines of engineering materials sciences physics and chemistry

**Analog Circuit Design** Johan Huijsing, Michiel Steyaert, Arthur H.M. van Roermund, 2013-03-20 Analog Circuit Design contains the contribution of 18 experts from the 13th International Workshop on Advances in Analog Circuit Design It is number 13 in the successful series of Analog Circuit Design It provides 18 excellent overviews of analog circuit design in Sensor and Actuator Interfaces Integrated High Voltage Electronics and Power Management and Low Power and High Resolution ADC s Analog Circuit Design is an essential reference source for analog circuits designers and researchers wishing to keep abreast with the latest developments in the field The tutorial coverage also makes it suitable for use in an advanced design course



## Decoding **High Accuracy Cmos Smart Temperature Sensors**: Revealing the Captivating Potential of Verbal Expression

In a time characterized by interconnectedness and an insatiable thirst for knowledge, the captivating potential of verbal expression has emerged as a formidable force. Its ability to evoke sentiments, stimulate introspection, and incite profound transformations is genuinely awe-inspiring. Within the pages of "**High Accuracy Cmos Smart Temperature Sensors**," a mesmerizing literary creation penned by way of a celebrated wordsmith, readers attempt an enlightening odyssey, unraveling the intricate significance of language and its enduring impact on our lives. In this appraisal, we shall explore the book's central themes, evaluate its distinctive writing style, and gauge its pervasive influence on the hearts and minds of its readership.

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