Low Power Crystal And Mems Oscillators The Experience Of Watch Developments Integrated Circuits And Systems

The book is a comprehensive treatment of the field, covering fundamental theoretical principles and new technological advancements, state-of-the-art device design, and reviewing examples encompassing a wide range of related sub-areas. In particular, the first area focuses on the recent development of novel wearable and implantable antenna concepts and designs including metamaterial-based wearable antennas, microwave circuit integrated wearable filtering antennas, and textile and/or fabric material enabled wearable antennas. The second set of topics covers advanced wireless propagation and the associated statistical models for on-body, in-body, and off-body modes. Other sub-areas such as efficient numerical human body modeling techniques, artificial phantom synthesis and fabrication, as well as low-power RF integrated circuits and related sensor technology are also discussed. These topics have been carefully selected for their transformational impact on the next generation of body-area network systems and beyond.

Micro and nano-electro-mechanical system (M/NEMS) devices constitute key technological building blocks to enable increased additional functionalities within Integrated Circuits (ICs) in the More-Than-Moore era, as described in the International Technology Roadmap for Semiconductors. The CMOS ICs and M/NEMS dies can be combined in the same package (SiP), or integrated within a single chip (SoC). In the SoC approach the M/NEMS devices are monolithically integrated together with CMOS circuitry allowing the development of compact and low-cost CMOS-M/NEMS devices for multiple applications (physical sensors, chemical sensors, biosensors, actuators, energy actuators, filters, mechanical relays, and others). On-chip CMOS electronics integration can overcome limitations related to the extremely low-level signals in sub-micrometer and nanometer scale electromechanical transducers enabling novel breakthrough applications. This Special Issue aims to gather high quality research contributions dealing with MEMS and NEMS devices monolithically integrated with CMOS, independently of the final application and fabrication approach adopted (MEMS-first, interleaved MEMS, MEMS-last or others).]

This book investigates the possible circuit solutions to overcome the temperature and supply voltage-sensitivity of fully-integrated time references for ultra-low-power communication in wireless sensor networks. The authors provide an elaborate theoretical introduction and literature study to enable full understanding of the design challenges and shortcomings of current oscillator implementations. Furthermore, a closer look to the short-term as well as the long-term frequency stability of integrated oscillators is taken. Next, a design strategy is developed and applied to 5 different oscillator topologies and 1 sensor interface. All 6 implementations are subject to an elaborate study of frequency stability, phase noise and power consumption. In the final chapter all blocks are compared to the state of the art.

The 4th edition of this popular Handbook continues to provide an easy-to-use guide to the many exciting new developments in the field of optical fiber data communications. With 90% new content, this edition contains all new material describing the transformation of the modern data communications network, both within the data center and over extended distances between data centers, along with best practices for the design of highly virtualized, converged, energy efficient, secure, and flattened network infrastructures. Key topics include networks for cloud computing, software defined networking, integrated and embedded networking appliances, and low latency networks for financial trading or other time-sensitive applications. Network architectures from the leading vendors are outlined (including Smart Analytic Solutions, Qfabric, FabricPath, and Exadata) as well as the latest revisions to industry standards for interoperable networks, including lossless Ethernet, 16G Fiber Channel, RoCE, FCoE, TRILL, IEEE 802.1Qbg, and more. Written by experts from IBM, HP, Dell, Cisco, Ciena, and Sun/ Oracle Case studies and ‘How to...’ demonstrations on a wide range of topics, including Optical Ethernet, next generation Internet, RDMA and Fiber Channel over Ethernet Quick reference tables of all the key optical network parameters for protocols like ESCON, FICON, and SONET/ATM and a glossary of technical terms and acronyms

Written at an intermediate level in a way that is easy to understand, Fundamentals and Applications of Ultrasonic Waves, Second Edition provides an up-to-date exposition of ultrasonics and some of its main applications. Designed specifically for newcomers to the field, this fully updated second edition emphasizes underlying physical concepts over mathematics. The first half covers the fundamentals of ultrasonic waves for isotropic media. Starting with bulk liquid and solid media, discussion extends to surface and plate effects, at which point the author introduces new modes such as Rayleigh and Lamb waves. This focus on only isotropic media simplifies the usually complex mathematics involved, enabling a clearer understanding of the underlying physics to avoid the complicated tensorial description characteristic of crystalline media. The second part of the book addresses a broad spectrum of industrial and research applications, including quartz crystal resonators, surface acoustic wave devices, MEMS and microacoustics, and acoustic sensors. It also provides a broad discussion on the use of ultrasonics for non-destructive evaluation. The author concentrates on the developing area of microacoustics, including exciting new work on the use of probe microscopy techniques in nanotechnology. Focusing on the physics of acoustic waves, as well as their propagation, technology, and applications, this book addresses viscoelasticity, as well as new concepts in acoustic microscopy. It updates coverage of ultrasonics in nature and developments in sonoluminescence, and it also compares new technologies, including use of atomic force acoustic microscopy and lasers. Highlighting both direct and indirect applications for readers working in neighboring disciplines, the author presents particularly important sections on the use of microacoustics and acoustic nanoprobes in next-generation devices and instruments.

In the high frequency world, the passive technologies required to realize RF and microwave functionality present distinctive challenges. SAW filters, dielectric resonators, MEMS, and waveguide do not have counterparts in the low frequency or digital environment. Even when conventional lumped components can be used in high frequency applications, their behavior does not resemble that observed at lower frequencies. RF and Microwave Passive and Active Technologies provides detailed information about a wide range of component technologies used in modern RF and microwave systems. Updated chapters include new material on such technologies as MEMS, device packaging, surface acoustic wave (SAW) filters, bipolar junction and heterojunction transistors, and high mobility electron transistors (HMETs). The book also features a completely rewritten section on wide bandgap transistors.

This book describes an alternative method of realizing accurate on-chip frequency references in standard CMOS processes. This method exploits the thermal-diffusivity of silicon, i.e. the rate at which heat diffuses through a silicon substrate. This is the first book describing the design of such electrothermal frequency references. It includes the necessary theory, supported by practical realizations that achieve inaccuracies as low as 0.1% and thus demonstrate the feasibility of this approach. The book also includes several circuit and system-level solutions to the precision circuit design challenges encountered during the design of such frequency references.

The power consumption of integrated circuits is one of the most problematic considerations affecting the design of high-performance chips and portable devices. The study of power-saving design methodologies now must also include subjects such as systems on chips, embedded software, and the future of microelectronics. Low-Power Electronics Design covers all major aspects of low-power design of ICs in deep submicron technologies and addresses emerging topics related to future design. This volume explores, in individual chapters written by expert authors, the many low-power techniques born during the past decade. It also discusses the many different domains and disciplines that impact power consumption, including processors, complex circuits, software, CAD tools, and energy sources and management. The authors delve into what many specialists predict about the future by presenting techniques that are promising but are not yet reality. They investigate nanotechnologies, optical circuits, ad hoc networks, e-textiles, as well as human powered sources of energy. Low-Power Electronics Design delivers a complete picture of today's methods for reducing power, and also illustrates the advances in chip design that may be commonplace 10 or 15 years from now.

Quartz, unique in its chemical, electrical, mechanical, and thermal properties, is used as a frequency control element in applications where stability of frequency is an absolute necessity. Without crystal controlled transmission, radio and television would not be possible in their present form. The quartz crystals allow the individual channels in communication systems to be spaced closer together to make better use of one of most precious resources -- wireless bandwidth. This book describes the characteristics of the art of crystal oscillator design, including how to specify and select crystal oscillators. While presenting various varieties of crystal oscillators, this resource also provides you with useful MathCad and Genesys simulations.

The importance and ubiquity of wireless networks in the modern age justifies the depth and scope of the chapters included in this book, with its special focus on sensors. Topics covered include MAC protocols, with one contribution offering a literature review on them. Energy efficiency is also important, with several chapters addressing cooperative beamforming, modern spatial-diversity techniques and MEMS. Hardware issues are addressed by a batch of chapters, on extending network coverage areas, CMOS RF transceivers, the use of an accelerometer sensor module and a fall-detection monitoring system and a couple of contributions on hierarchical paradigms in wireless sensor networks. More mathematical approaches are also included, with chapters on data aggregation tree construction and distributed localization algorithms.

This book is based on the 18 tutorials presented during the 24th workshop on Advances in Analog Circuit Design. Expert designers present readers with information about a variety of topics at the frontier of analog circuit design, including low-power and energy-efficient analog electronics, with specific contributions focusing on the design of efficient sensor interfaces and low-power RF systems. This book serves as a valuable reference to the state-of-the-art, for anyone involved in analog circuit research and development.

Covers the latest developments in PNT technologies, including integrated satellite navigation, sensor systems, and civil applications Featuring sixty-four chapters that are divided into six parts, this two-volume work provides comprehensive coverage of the state-of-the-art in satellite-based position, navigation, and timing (PNT) technologies and civilian applications. It also examines alternative navigation technologies based on other signals-of-opportunity and sensors and offers a comprehensive treatment on integrated PNT systems for consumer and commercial applications. Volume 1 of Position, Navigation, and Timing Technologies in the 21st Century: Integrated Satellite Navigation, Sensor Systems, and Civil Applications contains three parts and focuses on the satellite navigation systems, technologies, and engineering and scientific applications. It starts with a historical perspective of GPS development and other related PNT development. Current global and regional navigation satellite systems (GNSS and RNSS), their inter-operability, signal quality monitoring, satellite orbit and time synchronization, and ground- and satellite-based augmentation systems are examined. Recent progresses in satellite navigation receiver technologies and challenges for operations in multipath-rich urban environment, in handling spoofing and interference, and in ensuring PNT integrity are addressed. A section on satellite navigation for engineering and scientific applications finishes off the volume. Volume 2 of Position, Navigation, and Timing Technologies in the 21st Century: Integrated Satellite Navigation, Sensor Systems, and Civil Applications consists of three parts and addresses PNT using alternative signals and sensors and integrated PNT technologies for consumer and commercial applications. It looks at PNT using various radio signals-of-opportunity, atomic clock, optical, laser, magnetic field, celestial, MEMS and inertial sensors, as well as the concept of navigation from Low-Earth Orbiting (LEO) satellites. GNSS-INS integration, neuroscience of navigation, and animal navigation are also covered. The volume finishes off with a collection of work on contemporary PNT applications such as survey and mobile mapping, precision agriculture, wearable systems, automated driving, train control, commercial unmanned aircraft systems, aviation, and navigation in the unique Arctic environment. In addition, this text: Serves as a complete reference and handbook for professionals and students interested in the broad range of PNT subjects Includes chapters that focus on the latest developments in GNSS and other navigation sensors, techniques, and applications Illustrates interconnecting relationships between various types of technologies in order to assure more protected, tough, and accurate PNT Position, Navigation, and Timing Technologies in the 21st Century: Integrated Satellite Navigation, Sensor Systems, and Civil Applications will appeal to all industry professionals, researchers, and academics involved with the science, engineering, and applications of position, navigation, and timing technologies. pnt21book.com

In Optical Nano and Micro Actuator Technology, leading engineers, material scientists, chemists, physicists, laser scientists, and manufacturing specialists offer an in-depth, wide-ranging look at the fundamental and unique characteristics of light-driven optical actuators. They discuss how light can initiate physical movement and control a variety of mechanisms that perform mechanical work at the micro- and nanoscale. The book begins with the scientific background necessary for understanding light-driven systems, discussing the nature of light and the interaction between light and NEMS/MEMS devices. It then covers innovative optical actuator technologies that have been developed for many applications. The book examines photoresponsive materials that enable the design of optically driven structures and mechanisms and describes specific light-driven technologies that permit the manipulation of micro- and nanoscale objects. It also explores applications in optofluidics, bioMEMS and biophotonics, medical device design, and micromachine control. Inspiring the next generation of scientists and engineers to advance light-driven technologies, this book gives readers a solid grounding in this emerging interdisciplinary area. It thoroughly explains the scientific language and fundamental principles, provides a holistic view of optical nano and micro actuator systems, and illustrates current and potential applications of light-driven systems.

There is little question that the commercial success of smartphones has substantially increased the volume of products utilizing Micro Electro Mechanical Systems (MEMS) technology, especially accelerometers, gyroscopes, bandpass filters, and microphones. The Internet of Things (IoT), a more recent driver for small, low power microsystems, seems poised to provide an even bigger market for these and other potential products based on MEMS. Given that the IoT will likely depend heavily on massive sensor networks using nodes for which battery replacement might not be practical, cost and power consumption become even more important. As already known for existing sensor networks, sleep/wake cycles will likely be instrumental to maintaining low sensor node power consumption in the IoT, and if so, then the clocks that must continuously run to synchronize sleep/wake events often become the bottlenecks to ultimate power consumption. On the communications side, narrowband RF channel-selecting front-end filters stand to greatly reduce receive power consumption by relaxing transistor circuit dynamic ranges. Both the accuracy of the clocks and ability of filters to achieve bandwidths small enough to select individual channels depend heavily on the accuracy and precision to which the frequency-setting devices they rely on are constructed. Inevitably, fabrication tolerances are finite, which means the ability to attain the highest performance relies on trimming or tuning. This dissertation focuses on methods by which voltage-controlled frequency tuning of capacitively-transduced micromechanical resonators make possible 1) an ultra-compact, low-power 32.768-kHz micromechanical clock oscillator; and 2) a high-order, small percent bandwidth coupled-resonator filter with minimal passband distortion. Currently, quartz crystal-based oscillators at 32.768 kHz dominate the market because they offer the best combination of cost and performance. However, the physical dimensions of these oscillators are presently too large for future small form-factor electronic applications, such as ones that fit within credit cards. While there have been attempts to shrink quartz resonating elements, the increasingly difficult fabrication steps required to produce such devices raises manufacturing costs, thereby preventing widespread adoption (so far). In addition, quartz crystal motional resistance values typically increase as resonator dimensions shrink, which in many oscillator configurations raises power consumption. Unlike common quartz resonators, properly designed MEMS resonators benefit greatly from scaling in that reductions in lateral dimensions lead to a rapid decrease in motional resistance by a square law. The work described herein harnesses these scaling advantages to realize an oscillator much smaller than quartz-based oscillators with potential for much less power consumption. Specifically, this work uses aggressive lithography to achieve a capacitive-comb transduced micromechanical resonator occupying only 0.0154 mm2 of die area. Wire bonding this resonator to a custom sustaining amplifier and a supply voltage of only 1.65V then realizes a 32.768-kHz real-time clock oscillator more than 100× smaller by area than miniaturized quartz crystal implementations and at least 4× smaller than other MEMS-based approaches. The use of voltage-controlled tuning Oscillations sustains with only 2.1 [mu]W of power consumption. On the filter front, whether realized using quartz, FBAR, or capacitive-gap transduced MEMS resonator, mechanical filter responses are only as flat as the accuracy of their constituent resonator center frequencies. While narrowband micromechanical filters comprised of up to three mechanically coupled resonators have been demonstrated in the past, there exists a demand for bandpass filters with even sharper roll-offs and larger stopband rejections, and this requires higher order filters utilizing more than three coupled resonators. The work herein demonstrates filters comprised of four coupled resonators with bandwidths narrow enough to select individual channels. Before correction, filter passbands fresh out of the fab look nothing like their intended responses. Application of the automated passband correction protocol of this work, based on voltage-controlled frequency tuning, permits measurement of a 4-resonator micromechanical filter with a 0.1% bandwidth commensurate with the needs of channel-selection (albeit at a low frequency) and an impressive 20-dB shape factor of 1.59, all with less than 3dB of additional passband ripple (beyond the design ripple).

The power consumption of microprocessors is one of the most important challenges of high-performance chips and portable devices. In chapters drawn from Piguet's recently published Low-Power Electronics Design, this volume addresses the design of low-power microprocessors in deep submicron technologies. It provides a focused reference for specialists involved in systems-on-chips, from low-power microprocessors to DSP cores, reconfigurable processors, memories, ad-hoc networks, and embedded software. Low-Power Processors and Systems on Chips is organized into three broad sections for convenient access. The first section examines the design of digital signal processors for embedded applications and techniques for reducing dynamic and static power at the electrical and system levels. The second part describes several aspects of low-power systems on chips, including hardware and embedded software aspects, efficient data storage, networks-on-chips, and applications such as routing strategies in wireless RF sensing and actuating devices. The final section discusses embedded software issues, including details on compilers, retargetable compilers, and coverification tools. Providing detailed examinations contributed by leading experts, Low-Power Processors and Systems on Chips supplies authoritative information on how to maintain high performance while lowering power consumption in modern processors and SoCs. It is a must-read for anyone designing modern computers or embedded systems.

This book describes the development of core technologies to address two of the most challenging issues in research for future IT platform development, namely innovative device design and reduction of energy consumption. Three key devices, the FinFET, the TunnelFET, and the electromechanical nanoswitch are described with extensive details of use for practical applications. Energy issues are also covered in a tutorial fashion from material physics, through device technology, to innovative circuit design. The strength of this book lies in its holistic approach dealing with material trends, state-of-the-art of key devices, new examples of circuits and systems applications. This is the first of three books based on the Integrated Smart Sensors research project, which describe the development of innovative devices, circuits, and system-level enabling technologies. The aim of the project was to develop common platforms on which various devices and sensors can be loaded, and to create systems offering significant improvements in information processing speed, energy usage, and size. The book contains extensive reference lists and with over 200 figures introduces the reader to the general subject in a tutorial style, also addressing the state-of-the-art, allowing it to be used as a guide for starting researchers in these fields.

Space Microsystems and Micro/Nano Satellites covers the various reasoning and diverse applications of small satellites in both technical and regulatory aspects, also exploring the technical and operational innovations that are being introduced in the field. The Space Microsystem developed by the author is systematically introduced in this book, providing information on such topics as MEMS micro-magnetometers, MIMUs (Micro-inertia-measurement unit), micro-sun sensors, micro-star sensors, micro-propellers, micro-relays, etc. The book also examines the new technical standards, removal techniques or other methods that might help to address current problems, regulatory issues and procedures to ameliorate problems associated with small satellites, especially mounting levels of orbital debris and noncompliance with radio frequency and national licensing requirements, liabilities and export controls, Summarizing the scientific research experiences of the author and his team, this book holds a high scientific reference value as it gives readers comprehensive and thorough introductions to the micro/nano satellite and space applications of MEMS technology. Covers various reasoning and diverse applications for small satellites in both technical and regulatory aspects Represents the first publication that systematically introduces the Space Microsystem developed by the author Examines new technical standards, removal techniques and other methods that might help to address current problems, regulatory issues and procedures

Low power and low phase noise RF frequency references are essential for applications such as high performance ADCs, high speed serial data links, and low power radios. They constitute a multi-billion dollar market in today's electronic industry. Quartz crystal is the most commonly used mineral for generating a reference clock. However, it needs a complicated manufacturing process, which increases cost, and it cannot be integrated with CMOS circuits. This is reason why wafer scale high-Q MEMS resonators are becoming attractive alternatives to quartz owing to their small size, low cost and integration potential. However, oscillators using MEMS resonator perform poorly compared to quartz based oscillators in terms of close-in phase noise. Close-in phase noise is an important performance metric for a reference oscillator as it dominates the in-band phase noise of a frequency synthesizer in a radio. In addition, highly miniaturized MEMS resonator based oscillators have exhibited poor frequency stability over temperature. This characteristic is an issue, which limits the choice of the oscillator type in wireless application such as Bluetooth, Wi-Fi and GPS. The first part of this thesis addresses the close-in phase noise issue and proposes circuits with MEMS resonator such as AlN contour mode resonator and FBAR (thin-Film Bulk-Acoustic Resonator) to demonstrate solutions for improving the phase noise and lowering the power consumption. The proposed oscillator with FBAR culminates in achieving more than 10dB lower phase noise than that of conventional oscillator with 350uW power consumption. The following part of this thesis addresses the frequency drift of the reference clock when the temperature changes. The wireless application requires stringent and challenging spec. for the oscillator to generate a stable clock signal. For example, GPS needs to have less than 2ppm frequency drift over temperature. The first prototype of fully integrated oven-controlled temperature compensation system is thus introduced. This effort aims to have a ±1.6ppm stability reference clock with 150uK temperature resolution.

The book addresses the need to investigate new approaches to lower energy requirement in multiple application areas and serves as a guide into emerging circuit technologies. It explores revolutionary device concepts, sensors, and associated circuits and architectures that will greatly extend the practical engineering limits of energy-efficient computation. The book responds to the need to develop disruptive new system architecutres, circuit microarchitectures, and attendant device and interconnect technology aimed at achieving the highest level of computational energy efficiency for general purpose computing systems. Features Discusses unique technologies and material only available in specialized journal and conferences Covers emerging applications areas, such as ultra low power communications, emerging bio-electronics, and operation in extreme environments Explores broad circuit operation, ex. analog, RF, memory, and digital circuits Contains practical applications in the engineering field, as well as graduate studies Written by international experts from both academia and industry

Increase the efficient use of time-varying available spectrum with this unique book, the first to describe RF hardware design for white space applications, including both analog and digital approaches. Emerging technologies are discussed and signal processing issues are addressed, providing the background knowledge and practical tools needed to develop future radio technologies. Real-world examples are included, together with global spectrum regulations and policies, for a practical approach to developing technologies for worldwide applications. Cross analog and digital design guidelines are provided to help cut design time and cost. This holistic, system level view of transceiver design for white space technologies is ideal for practising engineers and students and researchers in academia.

This book introduces piezoelectric microelectromechanical (pMEMS) resonators to a broad audience by reviewing design techniques including use of finite element modeling, testing and qualification of resonators, and fabrication and large scale manufacturing techniques to help inspire future research and entrepreneurial activities in pMEMS. The authors discuss the most exciting developments in the area of materials and devices for the making of piezoelectric MEMS resonators, and offer direct examples of the technical challenges that need to be overcome in order to commercialize these types of devices.

Some of the topics covered include: Widely-used piezoelectric materials, as well as materials in which there is emerging interest Principle of operation and design approaches for the making of flexural, contour-mode, thickness-mode, and shear-mode piezoelectric resonators, and examples of practical implementation of these devices Large scale manufacturing approaches, with a focus on the practical aspects associated with testing and qualification Examples of commercialization paths for piezoelectric MEMS resonators in the timing and the filter markets ...and more! The authors present industry and academic perspectives, making this book ideal for engineers, graduate students, and researchers.

Aggressively duty-cycling the operation of a system between ON and OFF states has proven to be the most effective way to reduce the average power consumption in energy-constrained applications such as Internet-of-Things (IoT). Since these devices are either battery-powered with a very small form factor or rely on energy harvesting where small amount of ambient energy is captured to power up the device, ultra-low power consumption is crucial in enabling all the advantages that applications such as IoT and biomedical implantable/wearable devices are expected to produce. However, the amount of power saving in a duty-cycled system is usually constrained by two main factors: 1) the start-up time of the system; and 2) the OFF-state power consumption. The system start-up time is usually limited by the long start-up time of its reference oscillator, typically a high-Q, MHz-range crystal oscillator that usually takes several milliseconds to turn on. The OFF-state (sleep) power consumption, on the other hand, is dominated by the sleep timer that is an always-ON 32KHz crystal oscillator. Sleep timer synchronizes the transmitting and receiving bursts which requires a very accurate oscillation frequency to minimize the guard band in order to reduce the active energy consumption. To address the mentioned challenges, we have developed circuit techniques and architectures that enable low-power clock generation. To kick-start high-Q oscillators, such as crystal and/or MEMS-based reference oscillators, pre-energization of the resonator through injecting energy for a precise duration is proposed. A universal analysis for energy injection into high-Q resonators is developed and used to calculate the optimal injection duration essential to obtain a minimum start-up time. The proposed method ameliorates the sensitivity of the start-up time to the matching between the injection and resonance frequencies. To further relax the frequency accuracy requirement of the injection oscillator, energy injection with a dynamically-adjusted injection duration is presented. Measurement results from a 65nm CMOS IC show that the proposed technique reduces the start-up time of multiple tested crystal oscillators to about 100-120 number of oscillation cycles. The measured start-up time using the proposed precisely-timed energy injection method is 15 times faster than the best case reported in the literature while consuming the lowest start-up energy of ~12nJ. In order to reduce the sleep power consumption, an ultra-low power sleep timer that is based on a DC-only sustaining amplifier is presented. New oscillator architecture is proposed that enables sub-nW power consumption in a 32KHz crystal oscillator by amplifying the oscillation signal at DC, instead of amplifying it at the oscillation frequency. Measurement results of 20 different 65nm standard CMOS dies show an average power consumption of 0.55nW drawn from a 0.5V supply at room temperature for a 32KHz crystal oscillator. The measured long-term stability of the sleep timer indicated by the Allan deviation floor is 14ppb. The proposed oscillator architecture does not require any calibration schemes or multiple supply domains, unlike most prior art.

Low-Power Crystal and MEMS OscillatorsThe Experience of Watch DevelopmentsSpringer Science & Business Media

The recent shift in focus from defense and government work to commercial wireless efforts has caused the job of the typical microwave engineer to change dramatically. The modern microwave and RF engineer is expected to know customer expectations, market trends, manufacturing technologies, and factory models to a degree that is unprecedented in the

Microdisplays are tiny, high-resolution electronic displays, designed for use in magnifying optical systems such as HDTV projectors and near-eye personal viewers. As a result of research and development into this field, Microdisplays are incorporated in a variety of visual electronics, notably new 3G portable communications devices, digital camera technologies, wireless internet applications, portable DVD viewers and wearable PCs. Introduction to Microdisplays encapsulates this market through describing in detail the theory, structure, fabrication and applications of Microdisplays. In particular this book: Provides excellent reference material for the Microdisplay industry through including an overview of current applications alongside a guide to future developments in the field Covers all current technologies and devices such as Silicon Wafer Backplane Technology, Liquid Crystal Devices, Micromechanical Devices, and the emerging area of Organic Light Emitting Diodes Presents guidance on the design of applications of Microdisplays, including Microdisplays for defence and telecoms, from basic principles through to their performance limitations Introduction to Microdisplays is a thorough and comprehensive reference on this emerging topic. It is essential reading for display technology manufacturers, developers, and system integrators, as well as practising electrical engineers, physicists, chemists and specialists in the display field. Graduate students, researchers, and developers working in optics, material science, and telecommunications will also find this a valuable resource. The Society for Information Display (SID) is an international society, which has the aim of encouraging the development of all aspects of the field of information display. Complementary to the aims of the society, the Wiley-SID series is intended to explain the latest developments in information display technology at a professional level. The broad scope of the series addresses all facets of information displays from technical aspects through systems and prototypes to standards and ergonomics

This book is written for academic and professional researchers designing communication systems for pervasive and low power applications. There is an introduction to wireless sensor networks, but the main emphasis of the book is on design techniques for low power, highly integrated transceivers. Instead of presenting a single design perspective, this book presents the design philosophies from three diverse research groups, providing three completely different strategies for achieving similar goals. By presenting diverse perspectives, this book prepares the reader for the countless design decisions they will be making in their own designs.

Many argue that telecommunications network infrastructure is the most impressive and important technology ever developed. Analyzing the telecom market’s constantly evolving trends, research directions, infrastructure, and vital needs, Telecommunication Networks responds with revolutionized engineering strategies to optimize network construction. Omnipresent in society, telecom networks integrate a wide range of technologies. These include quantum field theory for the study of optical amplifiers, software architectures for network control, abstract algebra required to design error correction codes, and network, thermal, and mechanical modeling for equipment platform design. Illustrating how and why network developers make technical decisions, this book takes a practical engineering approach to systematically assess the network as a whole—from transmission to switching. Emphasizing a uniform bibliography and description of standards, it explores existing technical developments and the potential for projected alternative architectural paths, based on current market indicators. The author characterizes new device and equipment advances not just as quality improvements, but as specific responses to particular technical market necessities. Analyzing design problems to identify potential links and commonalities between different parts of the system, the book addresses interdependence of these elements and their individual influence on network evolution. It also considers power consumption and real estate, which sometimes outweigh engineering performance data in determining a product's success. To clarify the potential and limitations of each presented technology and system analysis, the book includes quantitative data inspired by real products and prototypes. Whenever possible, it applies mathematical modeling to present measured data, enabling the reader to apply demonstrated concepts in real-world situations. Covering everything from high-level architectural elements to more basic component physics, its focus is to solve a problem from different perspectives, and bridge descriptions of well-consolidated solutions with newer research trends.

Almost all imaginable electronic devices in common use today, including cell phones, laptops, music players, cameras, televisions, automobiles, appliances, and wristwatches, rely upon timing references of some kind. Traditionally, the timing references used in all of these applications have relied upon the same technology: quartz crystal oscillators. However, Microelectromechanical Systems (MEMS) oscillators have become a viable option and are replacing quartz in segments of the timing reference market. In part, this paradigm shift is based upon the improved size, cost, and reliability of MEMS solutions. Unfortunately, the temperature stability of MEMS oscillators is inferior to that of compensated quartz oscillators, and this is one of several shortcomings that have precluded the use of MEMS references in some high precision applications like wireless communication and navigation. This thesis presents the fundamental concepts behind MEMS resonator and oscillator operation as well as an overview of previously established temperature compensation schemes for MEMS devices. Details are provided on the MEMS technology used throughout this work, including Double Ended Tuning Fork (DETF) resonators, "epi-seal" encapsulation, and a variety of associated nonideal behaviors. Measurement data from several MEMS prototypes is also provided along with an overview of the concepts of phase noise and Allan variance. Two MEMS interface circuits are demonstrated. The first is an integrated transimpedance amplifier (TIA) designed specifically to interface with MEMS devices that exhibit very large motional impedance. The TIA consists of a capacitive-feedback current amplifier that drives current into an active load to obtain a 56 M[omega] transimpedance gain, 1.8 MHz bandwidth, phase response near 0 degrees, and 65 fA/[square root]Hz input-referred noise. The TIA was fabricated in 0.18 [mu]m CMOS technology and dissipates 436 [mu]W from a 1.8 V supply. The second circuit is a printed circuit board (PCB) implementation of a fully functional 1.2 MHz MEMS oscillator, including automatic level control. This PCB-based oscillator was used to flexibly test the MEMS prototypes used throughout the remainder of the thesis. Two active temperature compensation schemes that significantly improve the temperature stability of silicon MEMS oscillators are also demonstrated. Both schemes rely on micro-oven based compensation, using micro-scale thermal isolation and heating to maintain a MEMS resonator at a constant elevated temperature. The power consumption for the micro-ovens used in this work was in the range of 9 to 15 mW for a 100 degrees C operation range. The first temperature compensation scheme, called "Q(T)-based temperature compensation, " uses resonator quality factor as a proxy for temperature in a closed loop feedback system. This system achieved frequency stability of +/-25 ppm over a temperature range of 0 to 70 degrees C with a single-point calibration or +/-1 ppm with a multi-point calibration, but suffered from the limitations of considerable calibration overhead and poor long term stability. In particular, the Q(T) system's sensitivity to the analog gain of the components in the temperature sensing feedback path proved to be a major hindrance to this system's performance. The second scheme, called "[delta]f-based temperature compensation, " uses a phase lock loop and an integrated micro-oven to achieve temperature compensation. The phase lock loop monitors the difference frequency between two resonators with different temperature coefficients. This difference frequency provides a high resolution measurement of the resonators' temperature and is compared to a reference frequency derived from one of the resonators. Negative feedback is then used to drive the difference between the difference frequency and the reference frequency to zero by applying heat to the micro-oven. This procedure ensures that the micro-oven is held at a constant temperature despite variations in ambient temperature, thereby allowing the [delta]f system to maintain sub-ppm frequency stability under transient temperature conditions from -20 to 80 degrees C and part-per-billion level Allan deviation in an uncontrolled environment. Additional calibration is shown to reduce the steady-state temperature stability to the range of +/-60 ppb. It is hoped that this novel temperature scheme may facilitate the use of low power, low cost, space saving MEMS oscillators in a new arena of high precision timing reference applications.

The Encyclopedia of Modern Optics, Second Edition, provides a wide-ranging overview of the field, comprising authoritative reference articles for undergraduate and postgraduate students and those researching outside their area of expertise. Topics covered include classical and quantum optics, lasers, optical fibers and optical fiber systems, optical materials and light-emitting diodes (LEDs). Articles cover all subfields of optical physics and engineering, such as electro-optical design of modulators and detectors. This update contains contributions from international experts who discuss topics such as nano-photonics and plasmonics, optical interconnects, photonic crystals and 2D materials, such as graphene or holy fibers. Other topics of note include solar energy, high efficiency LED's and their use in illumination, orbital angular momentum, quantum optics and information, metamaterials and transformation optics, high power fiber and UV fiber lasers, random lasers and bio-imaging. Addresses recent developments in the field and integrates concepts from fundamental physics with applications for manufacturing and engineering/design Provides a broad and interdisciplinary coverage of specialist areas Ensures that the material is appropriate for new researchers and those working in a new sub-field, as well as those in industry Thematically arranged and alphabetically indexed, with cross-references added to facilitate ease-of-use

MEMS-based Circuits and Systems for Wireless Communications provides comprehensive coverage of RF-MEMS technology from device to system level. This edited volume places emphasis on how system performance for radio frequency applications can be leveraged by Micro-Electro-Mechanical Systems (MEMS). Coverage also extends to innovative MEMS-aware radio architectures that push the potential of MEMS technology further ahead. This work presents a broad overview of the technology from MEMS devices (mainly BAW and Si MEMS resonators) to basic circuits, such as oscillators and filters, and finally complete systems such as ultra-low-power MEMS-based radios. Contributions from leading experts around the world are organized in three parts. Part I introduces RF-MEMS technology, devices and modeling and includes a prospective outlook on ongoing developments towards Nano-Electro-Mechanical Systems (NEMS) and phononic crystals. Device properties and models are presented in a circuit oriented perspective. Part II focusses on design of electronic circuits incorporating MEMS. Circuit design techniques specific to MEMS resonators are applied to oscillators and active filters. In Part III contributors discuss how MEMS can advantageously be used in radios to increase their miniaturization and reduce their power consumption. RF systems built around MEMS components such as MEMS-based frequency synthesis including all-digital PLLs, ultra-low power MEMS-based communication systems and a MEMS-based automotive wireless sensor node are described.

Electronic oscillators using an electromechanical device as a frequency reference are irreplaceable components of systems-on-chip for time-keeping, carrier frequency generation and digital clock generation. With their excellent frequency stability and very large quality factor Q, quartz crystal resonators have been the dominant solution for more than 70 years. But new possibilities are now offered by micro-electro-mechanical (MEM) resonators, that have a qualitatively identical equivalent electrical circuit. Low-Power Crystal and MEMS Oscillators concentrates on the analysis and design of the most important schemes of integrated oscillator circuits. It explains how these circuits can be optimized by best exploiting the very high Q of the resonator to achieve the minimum power consumption compatible with the requirements on frequency stability and phase noise. The author has 40 years of experience in designing very low-power, high-performance quartz oscillators for watches and other battery operated systems and has accumulated most of the material during this period. Some additional original material related to phase noise has been added. The explanations are mainly supported by analytical developments, whereas computer simulation is limited to numerical examples. The main part is dedicated to the most important Pierce circuit, with a full design procedure illustrated by examples. Symmetrical circuits that became popular for modern telecommunication systems are analyzed in a last chapter.

This is the first text to cover all aspects of solution processed functional oxide thin-films. Chemical Solution Deposition (CSD) comprises all solution based thin- film deposition techniques, which involve chemical reactions of precursors during the formation of the oxide films, i. e. sol-gel type routes, metallo-organic decomposition routes, hybrid routes, etc. While the development of sol-gel type processes for optical coatings on glass by silicon dioxide and titanium dioxide dates from the mid-20th century, the first CSD derived electronic oxide thin films, such as lead zirconate titanate, were prepared in the 1980’s. Since then CSD has emerged as a highly flexible and cost-effective technique for the fabrication of a very wide variety of functional oxide thin films. Application areas include, for example, integrated dielectric capacitors, ferroelectric random access memories, pyroelectric infrared detectors, piezoelectric micro-electromechanical systems, antireflective coatings, optical filters, conducting-, transparent conducting-, and superconducting layers, luminescent coatings, gas sensors, thin film solid-oxide fuel cells, and photoelectrocatalytic solar cells. In the appendix detailed “cooking recipes” for selected material systems are offered.

This book is based on the 18 invited tutorials presented during the 27th workshop on Advances in Analog Circuit Design. Expert designers from both industry and academia present readers with information about a variety of topics at the frontiers of analog circuit design, including the design of analog circuits in power-constrained applications, CMOS-compatible sensors for mobile devices and energy-efficient amplifiers and drivers. For anyone involved in the design of analog circuits, this book will serve as a valuable guide to the current state-of-the-art. Provides a state-of-the-art reference in analog circuit design, written by experts from industry and academia; Presents material in a tutorial-based format; Covers the design of analog circuits in power-constrained applications, CMOS-compatible sensors for mobile devices and energy-efficient amplifiers and drivers.

This groundbreaking book provides you with a comprehensive understanding of FBAR (thin-film bulk acoustic wave resonator), MEMS (microelectomechanical system), and NEMS (nanoelectromechanical system) resonators. For the first time anywhere, you find extensive coverage of these devices at both the technology and application levels. This practical reference offers you guidance in design, fabrication, and characterization of FBARs, MEMS and NEBS. It discusses the integration of these devices with standard CMOS (complementary-metal-oxide-semiconductor) technologies, and their application to sensing and RF systems. Moreover, this one-stop resource looks at the main characteristics, differences, and limitations of FBAR, MEMS, and NEMS devices, helping you to choose the right approaches for your projects. Over 280 illustrations and more than 130 equations support key topics throughout the book.

This book explores the design of ultra-low-power radio-frequency integrated circuits (RFICs), with communication distances ranging from a few centimeters to a few meters. The authors describe leading-edge techniques to achieve ultra-low-power communication over short-range links. Many different applications are covered, ranging from body-area networks to transcutaneous implant communications and smart-appliance sensor networks. Various design techniques are explained to facilitate each of these applications.

The field of low-dimensional structures has been experiencing rapid development in both theoretical and experimental research. Phonons in Low Dimensional Structures is a collection of chapters related to the properties of solid-state structures dependent on lattice vibrations. The book is divided into two parts. In the first part, research topics such as interface phonons and polaron states, carrier-phonon non-equilibrium dynamics, directional projection of elastic waves in parallel array of N elastically coupled waveguides, collective dynamics for longitudinal and transverse phonon modes, and elastic properties for bulk metallic glasses are related to semiconductor devices and metallic glasses devices. The second part of the book contains, among others, topics related to superconductor, phononic crystal carbon nanotube devices such as phonon dispersion calculations using density functional theory for a range of superconducting materials, phononic crystal-based MEMS resonators, absorption of acoustic phonons in the hyper-sound regime in fluorine-modified carbon nanotubes and single-walled nanotubes, phonon transport in carbon nanotubes, quantization of phonon thermal conductance, and phonon Anderson localization.

Frequency reference oscillator is a critical component of modern radio transceivers. Currently, most reference oscillators are based on low-frequency quartz crystals that are inherently bulky and incompatible with standard micro-fabrication processes. Moreover, their frequency limitation (200MHz) requires large up-conversion ratio in multigigahertz frequency synthesizers, which in turn, degrades the phase-noise. Recent advances in MEMS technology have made realization of high-frequency on-chip low phase-noise MEMS oscillators possible. Although significant research has been directed toward replacing quartz crystal oscillators with integrated micromechanical oscillators, their phase-noise performance is not well modeled. In addition, little attention has been paid to developing electronic frequency tuning techniques to compensate for temperature/process variation and improve the absolute frequency accuracy. The objective of this dissertation was to realize high-frequency temperature-compensated high-frequency (100MHz) micromechanical oscillators and study their phase-noise performance. To this end, low-power low-noise CMOS transimpedance amplifiers (TIA) that employ novel gain and bandwidth enhancement techniques are interfaced with high frequency (>100MHz) micromechanical resonators. The oscillation frequency is varied by a tuning network that uses frequency tuning enhancement techniques to increase the tuning range with minimal effect on the phase-noise performance. Taking advantage of extended frequency tuning range, and on-chip temperature-compensation circuitry is embedded with the sustaining circuitry to electronically temperature-compensate the oscillator. Finally, detailed study of the phase-noise in micromechanical oscillators is performed and analytical phase-noise models are derived.

Wireless technology, which already plays a major part in our daily lives, is expected to further expand to networks of billions of autonomous sensors in coming years: the so-called Internet of Things. In one vision, sensors employing low-cost, low-power wireless motes collect and transmit data through a mesh network while operating only on scavenged or battery power. RF MEMS provides one approach to the stringent power and performance required by sensor networks. This dissertation presents improvement to these MEMS technologies and introduces new approaches for wireless communication in low power wireless networks. First, this work presents oscillators based on the capacitive-gap transduced MEMS resonator. As wireless radio needs at least one such oscillator, the space and power savings offered by these MEMS oscillators make them compelling alternatives over bulky quartz-based devices. The high quality factors (Q) > 100,000 possible in these on-chip resonators allow for phase noise performance of the oscillator exceeding even the challenging GSM specifications using less than 100 uW of power consumption. Despite their small size and tiny capacitive gaps, MEMS-based oscillators are found to be insensitive to vibration and achieve only a few ppm shift in frequency over 10 months of measurement: the performance shown is on par or better than the off-the-shelf crystal oscillators. Interestingly, exploiting nonlinearities in the MEMS resonators also allows multiple simultaneous oscillation frequencies using one amplifier. Combined with electrical stiffness-based frequency tuning, this enables Frequency-Shift Keyed modulation of the output waveform, offering a space and power-efficient multichannel transmitter, as desired for mobile applications requiring long battery life. Intrinsically, oscillator systems involve positive feedback loops, which regeneratively amplify signals in the loop. Taking advantage of this property, MEMS oscillator systems may be used for other wireless signal processing applications. This dissertation explores such systems applied to: 1) a narrow channel-select filter with low insertion loss unachievable using passive resonators only and 2) a super-regenerative amplification-based channel-selecting radio transceiver. Finally, this dissertation presents two capacitive-gap transduced micromechanical resonator designs which can achieve the high Q at GHz frequencies needed for many wireless communication standards. The methods and solutions provided here pave a path towards realization of future low-power wireless technologies.