Electromagnetic Vibration Energy Harvesting Devices Architectures Design Modeling And Optimization Springer Series In Advanced Microelectronics

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Mechanical Systems, Classical Models

Scientifically defined in 1880 by the Curie brothers, piezoelectricity - from the Greek piezein, meaning to press (squeeze), and ilektron, meaning amber, a material with electrostatic properties - is a phenomenon with many applications. The related piezoelectric materials have been undergoing a long-lasting evolution over the years until today. The field of organic and inorganic piezoelectric materials is continuously expanding in terms of new substances used, new structures, and new applications. The seven chapters of this book present modern aspects and technological advances in the field of piezoelectric materials and applications. To present a balanced view of the field, some chapters focus on new piezoelectric materials and structures, while

others examine interesting applications of piezoelectric sensors, energy harvesters, and actuators.

Handbook of Energy Harvesting Power Supplies and Applications

This book contains chapters that discuss numerous methods and techniques in energy harvesting. Both theoretical and experimental results are presented from investigations that were carried out in the various chapters. Well-grounding methods and techniques presented in the new areas provide a good head start not only to those with interest in energy harvesting but also to experienced researchers who may want to look at energy harvesting from different angles. The concepts of energy harvesting are well articulated in the introduction of each chapter. It is my sincere hope that the readers of this book will find it a useful fountain of knowledge in energy harvesting.

Renewable Energy

Energy Harvesting

With its inclusion of the fundamentals, systems and applications, this reference provides readers with the basics of micro energy conversion along with expert knowledge on system electronics and real-life microdevices. The authors address different aspects of energy harvesting at the micro scale with a focus

on miniaturized and microfabricated devices. Along the way they provide an overview of the field by compiling knowledge on the design, materials development, device realization and aspects of system integration, covering emerging technologies, as well as applications in power management, energy storage, medicine and low-power system electronics. In addition, they survey the energy harvesting principles based on chemical, thermal, mechanical, as well as hybrid and nanotechnology approaches. In unparalleled detail this volume presents the complete picture -- and a peek into the future -- of micro-powered microsystems.

Micro and Nano Energy Harvesting Technologies

Electromagnetic vibration transducers are seen as an effective way of harvesting ambient energy for the supply of sensor monitoring systems. Different electromagnetic coupling architectures have been employed but no comprehensive comparison with respect to their output performance has been carried out up to now. Electromagnetic Vibration Energy Harvesting Devices introduces an optimization approach which is applied to determine optimal dimensions of the components (magnet, coil and back iron). Eight different commonly applied coupling architectures are investigated. The results show that correct dimensions are of great significance for maximizing the efficiency of the energy conversion. A comparison yields the architectures with the best output performance capability which should be

preferably employed in applications. A prototype development is used to demonstrate how the optimization calculations can be integrated into the design–flow. Electromagnetic Vibration Energy Harvesting Devices targets the designer of electromagnetic vibration transducers who wishes to have a greater in-depth understanding for maximizing the output performance.

Energy Harvesting Systems

In a previous volume (ICT-Energy-Concepts Towards Zero-Power ICT; referenced below as Vol. 1), we addressed some of the fundamentals related to bridging the gap between the amount of energy required to operate portable/mobile ICT systems and the amount of energy available from ambient sources. The only viable solution appears to be to attack the gap from both sides, i.e. to reduce the amount of energy dissipated during computation and to improve the efficiency in energy-harvesting technologies. In this book, we build on those concepts and continue the discussion on energy efficiency and sustainability by addressing the minimisation of energy consumption at different levels across the ICT system stack, from hardware to software, as well as discussing energy consumption issues in high-performance computing (HPC), data centres and communication in sensor networks. This book was realised thanks to the contribution of the project 'Coordinating Research Efforts of the ICT-Energy Community' funded from the European Union under the Future and Emerging Technologies (FET) area of

the Seventh Framework Programme for Research and Technological Development (grant agreement n. 611004).

Piezoelectric Materials

The field of digital signal processing (DSP) has spurred developments from basic theory of discrete-time signals and processing tools to diverse applications in telecommunications, speech and acoustics, radar, and video. This volume provides an accessible reference, offering theoretical and practical information to the audience of DSP users. This immense compilation outlines both introductory and specialized aspects of information-bearing signals in digital form, creating a resource relevant to the expanding needs of the engineering community. It also explores the use of computers and special-purpose digital hardware in extracting information or transforming signals in advantageous ways. Impacted areas presented include: Telecommunications Computer engineering Acoustics Seismic data analysis DSP software and hardware Image and video processing Remote sensing Multimedia applications Medical technology Radar and sonar applications This authoritative collaboration, written by the foremost researchers and practitioners in their fields, comprehensively presents the range of DSP: from theory to application, from algorithms to hardware.

Micro Energy Harvesting

MEMS by becoming a part of various applications

ranging from smartphones to automobiles has become an integral part of our everyday life. MEMS is building synergy between previously unrelated fields such as biology, microelectronics and communications, to improve the quality of human life. The sensors in MEMS gather information from the surrounding, which is then processed by the electronics for decision-making to control the environment. MEMS offers opportunities to miniaturize devices, integrate them with electronics and realize cost savings through batch fabrication. MEMS technology has enhanced many important applications in domains such as consumer electronics, biotechnology and communication and it holds great promise for continued contributions in the future. This book focuses on understanding the design, development and various applications of MEMS sensors.

Energy Harvesting for Autonomous Systems

Extensively revised and expanded to present the state-of-the-art in the field of magnetic design, this third edition presents a practical approach to transformer and inductor design and covers extensively essential topics such as the area product, Ap, and core geometry, Kg. The book provides complete information on magnetic materials and core characteristics using step-by-step design examples and presents all the key components for the design of lightweight, high-frequency aerospace transformers or low-frequency commercial transformers. Written by

a specialist with more than 47 years of experience in the field, this volume covers magnetic design theory with all of the relevant formulas.

Engineering and Scientific Computing with Scilab

Seeking renewable and clean energies is essential for releasing the heavy reliance on mineral-based energy and remedying the threat of global warming to our environment. In the last decade, explosive growth in research and development efforts devoted to microelectromechanical systems (MEMS) technology and nanowires-related nanotechnology have paved a great foundation for new mechanisms of harvesting mechanical energy at the micro/nano-meter scale. MEMS-based inertial sensors have been the enabler for numerous applications associated with smart phones, tablets, and mobile electronics. This is a valuable reference for all those faced with the challenging problems created by the ever-increasing interest in MEMS and nanotechnology-based energy harvesters and their applications. This book presents fundamental physics, theoretical design, and method of modeling for four mainstream energy harvesting mechanisms -- piezoelectric, electromagnetic, electrostatic, and triboelectric. Readers are provided with a comprehensive technical review and historical view of each mechanism. The authors also present current challenges in energy harvesting technology, technical reviews, design requirements, case studies, along with unique and representative examples of energy harvester applications.

Advances in Energy Harvesting Methods

Wireless sensors and sensor networks (WSNs) are nowadays becoming increasingly important due to their decisive advantages. Different trends towards the Internet of Things (IoT), Industry 4.0 and 5G Networks address massive sensing and admit to have wireless sensors delivering measurement data directly to the Web in a reliable and easy manner. These sensors can only be supported, if sufficient energy efficiency and flexible solutions are developed for energy-aware wireless sensor nodes. In the last years, different possibilities for energy harvesting have been investigated showing a high level of maturity. This book gives therefore an overview on fundamentals and techniques for energy harvesting and energy transfer from different points of view. Different techniques and methods for energy transfer, management and energy saving on network level are reported together with selected interesting applications. The book is interesting for researchers, developers and students in the field of sensors, wireless sensors, WSNs, IoT and manifold application fields using related technologies. The book is organized in four major parts. The first part of the book introduces essential fundamentals and methods, while the second part focusses on vibration converters and hybridization. The third part is dedicated to wireless energy transfer, including both RF and inductive energy transfer. Finally, the fourth part of the book treats energy saving and management strategies. The main contents are: Essential fundamentals and methods of wireless

sensors Energy harvesting from vibration Hybrid vibration energy converters Electromagnetic transducers Piezoelectric transducers Magneto-electric transducers Non-linear broadband converters Energy transfer via magnetic fields RF energy transfer Energy saving techniques Energy management strategies Energy management on network level Applications in agriculture Applications in structural health monitoring Application in power grids Prof. Dr. Olfa Kanoun is professor for measurement and sensor technology at Chemnitz university of technology. She is specialist in the field of sensors and sensor systems design.

The Power Harvesting Ratio

Advances in Energy Harvesting Methods presents a state-of-the-art understanding of diverse aspects of energy harvesting with a focus on: broadband energy conversion, new concepts in electronic circuits, and novel materials. This book covers recent advances in energy harvesting using different transduction mechanisms; these include methods of performance enhancement using nonlinear effects, non-harmonic forms of excitation and non-resonant energy harvesting, fluidic energy harvesting, and advances in both low-power electronics as well as material science. The contributors include a brief literature review of prior research with each chapter for further reference.

Piezoelectric Energy Harvesting Via Frequency Up-conversion Technology

This book deals with the challenge of exploiting ambient vibrational energy which can be used to power small and low-power electronic devices, e.g. wireless sensor nodes. Generally, particularly for low voltage amplitudes, low-loss rectification is required to achieve high conversion efficiency. In the special case of piezoelectric energy harvesting, pulsed charge extraction has the potential to extract more power compared to a single rectifier. For this purpose, a fully autonomous CMOS integrated interface circuit for piezoelectric generators which fulfills these requirements is presented. Due to these key properties enabling universal usage, other CMOS designers working in the field of energy harvesting will be encouraged to use some of the shown structures for their own implementations. The book is unique in the sense that it highlights the design process from scratch to the final chip. Hence, it gives the designer a comprehensive guide of how to (i) setup an appropriate harvester model to get realistic simulation results, (ii) design the integrated circuits for low power operation, (iii) setup a laboratory measurement environment in order to extensively characterize the chip in combination with the real harvester and finally, (iv) interpret the simulation/measurement results in order to improve the chip performance. Since the dimensions of all devices (transistors, resistors etc.) are given, readers and other designers can easily re-use the presented circuit concepts.

Piezoelectric Energy Harvesting

The science and technology in the area of piezoelectric ceramics are extremely progressing, especially the materials research, measurement technique, theory and applications, and furthermore, demanded to fit social technical requests such as environmental problems. While they had been concentrated on piezoelectric ceramics composed of lead-containing compositions, such as lead zirconate titanate (PZT) and lead titanate, at the beginning because of the high piezoelectricity, recently lead water pollution by soluble PZT of our environment must be considered. Therefore, different new compositions of lead-free ceramics in order to replace PZT are needed. Until now, there have been many studies on lead-free ceramics looking for new morphotropic phase boundaries, ceramic microstructure control to realize high ceramic density, including composites and texture developments, and applications to new evaluation techniques to search for high piezoelectricity. The purpose of this book is focused on the latest reports in piezoelectric materials such as lead-free ceramics, single crystals, and thin films from viewpoints of piezoelectric materials, piezoelectric science, and piezoelectric applications.

Modeling, Analysis and Experimental Validation of a Three Degree of Freedom Electromagnetic Energy Harvester

Ambient energy harvesting has attracted significant attention over the last years for applications such as wireless sensors, implantable devices, health monitoring systems, and wearable devices. The

methods of vibration-to-electric energy conversion can be included in the following categories: electromagnetic, electrostatic, and piezoelectric. Among various techniques of vibration-based energy harvesting, piezoelectric transduction method has received the most attention due to the large power density of the piezoelectric material and its simple architectures. In contrast to electromagnetic energy harvesting, the output voltage of a piezoelectric energy harvester is high, which can charge a storage component such as a battery. Compared to electrostatic energy harvester, the piezoelectric energy harvester does not require an external voltage supply. Also, piezoelectric harvesters can be manufactured in micro-scale, where they show better performance compared to other energy harvesters, owing to the well-established thick-film and thin-film fabrication techniques. The main drawback of the linear piezoelectric harvesters is that they only retrieve energy efficiently when they are excited at their resonance frequencies, which are usually high, while they are less efficient when the excitation frequency is distributed over a broad spectrum or is dominant at low frequencies. High-frequency vibrations can be found in machinery and vehicles could be used as the energy source but, most of the vibration energy harvesters are targeting at low-frequency vibration sources which are more achievable in the natural environment. One way to overcome this limitation is by using the frequency-up-conversion technology via impacts, where the source of the impacts can be one or two stoppers or more massive beams. The impact makes the piezoelectric beam oscillate in its resonance frequency and brings

nonlinear behavior into the system. The goal of this research is to enhance the piezoelectric harvester's energy retrieving performance from ambient vibrations with low or varying frequencies. In this work, impact-based piezoelectric energy harvesters were studied by discontinuous mapping dynamics. Discontinuous dynamics has been extensively applied in mechanical dynamics and physics field. Since the nature of the most environmental vibrations is periodic, periodic motions of the impact-based piezoelectric harvester were studied. Four different possible motion phases have been identified and categorized based on the performance of the output energy of the system. Many periodic motions are possible depending on the physical properties of the energy harvester setup. So far, we studied three different periodic motions of two beams interacting with each others, where period-1 and period-2 motions of the system are predicted. The stability of the system were analyzed and bifurcation graphs for each periodic motions were presented.

Micro Energy Harvesting

Supplementary files run on UNIX and Windows 95/98/NT

MEMS Sensors

The demand for portable permanent sources of electrical energy increases every day to power portable or non-accessible devices. Energy harvesting from vibrations offers a non-traditional source of

energy. It is renewable and prevailing, since nature around is rich in kinetic energy that can be harvested. In this work, we have developed two mechanisms to harvest energy from low-frequency vibrations present in nature using electromagnetic transduction. The harvesting mechanisms use a mass-on-spring mechanical oscillator to capture kinetic energy from a host body. Prototypes embodying the two harvesting mechanisms were fabricated and tested. We identi ed the system parameters of the harvester prototypes and generated their frequency-response curves. We analyzed the results using and compared them with mathematical models of the system dynamics to characterize the harvesters' performance including their output power, center frequency, and harvesting bandwidth. We were successful in demonstrating energy harvesters that can harvest low-frequency vibration with center frequencies in the range of 8-14 Hz, harvesting bandwidth in the range of 8-12Hz, and output power on the order of 1mW. The realized harvesters are relatively small, a few inches in dimension, and light, a few tens of grams in mass. We also introduced a novel electromagnetic transduction mechanism that can be used in harvesting low-frequency vibrations.

Magnetic Materials, Processes, and Devices 13

This book gathers the proceedings of the 15th IFToMM World Congress, which was held in Krakow, Poland, from June 30 to July 4, 2019. Having been organized every four years since 1965, the Congress represents

the world's largest scientific event on mechanism and machine science (MMS). The contributions cover an extremely diverse range of topics, including biomechanical engineering, computational kinematics, design methodologies, dynamics of machinery, multibody dynamics, gearing and transmissions, history of MMS, linkage and mechanical controls, robotics and mechatronics, micro-mechanisms, reliability of machines and mechanisms, rotor dynamics, standardization of terminology, sustainable energy systems, transportation machinery, tribology and vibration. Selected by means of a rigorous international peer-review process, they highlight numerous exciting advances and ideas that will spur novel research directions and foster new multidisciplinary collaborations.

Low Frequency Vibration Energy Harvesting Based on Free/Impact Motion

Frequency Analysis of Vibration Energy Harvesting Systems aims to present unique frequency response methods for analyzing and improving vibration energy harvesting systems. Vibration energy is usually converted into heat energy, which is transferred to and wasted in the environment. If this vibration energy can be converted into useful electric energy, both the performance and energy efficiency of machines, vehicles, and structures will be improved, and new opportunities will open up for powering electronic devices. To make use of ambient vibration energy, an effective analysis and design method is

established and developed in this book. The book covers a wide range of frequency response analysis methods and includes details of a variety of real-life applications. MATLAB programming is introduced in the first two chapters and used in selected methods throughout the book. Using the methods studied, readers will learn how to analyze and optimize the efficiency of vibration energy systems. This book will be ideal for postgraduate students and researchers in mechanical and energy engineering. Covers a variety of frequency response analysis methods, including Fourier and Laplace transform, transfer function, integration and state space for piezoelectric and electromagnetic vibration energy harvesting analysis Provides coverage of new and traditional methods of analyzing and optimizing the power and efficiency of vibration energy harvesting systems, with MATLAB exercises provided throughout Demonstrates a wide range of real-life applications, such as ocean wave energy conversion, vehicle suspension vibration energy harvesting, and more

Energy Harvesting Technologies

This unique resource provides a detailed understanding of the options for harvesting energy from localized, renewable sources to supply power to autonomous wireless systems. You are introduced to a variety of types of autonomous system and wireless networks and discover the capabilities of existing battery-based solutions, RF solutions, and fuel cells. The book focuses on the most promising harvesting techniques, including solar, kinetic, and thermal

energy. You also learn the implications of the energy harvesting techniques on the design of the power management electronics in a system. This in-depth reference discusses each energy harvesting approach in detail, comparing and contrasting its potential in the field.

CMOS Circuits for Electromagnetic Vibration Transducers

Chip-integrated power management solutions are a must for ultra-low power systems. This enables not only the optimization of innovative sensor applications. It is also essential for integration and miniaturization of energy harvesting supply strategies of portable and autonomous monitoring systems. The book particularly addresses interfaces for energy harvesting, which are the key element to connect micro transducers to energy storage elements. Main features of the book are: - A comprehensive technology and application review, basics on transducer mechanics, fundamental circuit and control design, prototyping and testing, up to sensor system supply and applications. - Novel interfacing concepts - including active rectifiers, MPPT methods for efficient tracking of DC as well as AC sources, and a fully-integrated charge pump for efficient maximum AC power tracking at sub-100µW ultra-low power levels. The chips achieve one of widest presented operational voltage range in standard CMOS technology: 0.44V to over 4.1V. - Two special chapters on analog circuit design – it studies benefits and obstacles on implemented chip prototypes with

three goals: ultra- low power, wide supply voltage range, and integration with standard technologies. Alternative design approaches are pursued using bulk-input transistor stages in forward-bias operation for amplifiers, modulators, and references. - Comprehensive Appendix – with additional fundamental analysis, design and scaling guidelines, circuit implementation tables and dimensions, schematics, source code listings, bill of material, etc. The discussed prototypes and given design guidelines are tested with real vibration transducer devices. The intended readership is graduate students in advanced courses, academics and lecturers, R&D engineers.

Design, Fabrication, and Testing of Piezoelectric Energy Harvesters

This book gathers papers presented at Mechatronics 2019, an international conference held in Warsaw, Poland, from September 16 to 18, 2019. The contributions discuss the numerous, multidisciplinary technological advances in the field of applied mechatronics that the emerging Industry 4.0 has already yielded. Each chapter presents a particular example of interdisciplinary theoretical knowledge, numerical modelling and simulation, or the application of artificial intelligence techniques. Further, the papers show how both software and physical devices can be incorporated into mechatronic systems to increase production efficiency and resource savings. The results and guidelines presented here will benefit both scientists and engineers looking for solutions to specific

industrial and research problems.

Micro-scale and Nonlinear Vibrational Energy Harvesting

In the early 21st century, research and development of sustainable energy harvesting (EH) technologies have started. Since then, many EH technologies have evolved, advanced and even been successfully developed into hardware prototypes for sustaining the operational lifetime of low?power electronic devices like mobile gadgets, smart wireless sensor networks, etc. Energy harvesting is a technology that harvests freely available renewable energy from the ambient environment to recharge or put used energy back into the energy storage devices without the hassle of disrupting or even discontinuing the normal operation of the specific application. With the prior knowledge and experience developed over a decade ago, progress of sustainable EH technologies research is still intact and ongoing. EH technologies are starting to mature and strong synergies are formulating with dedicate application areas. To move forward, now would be a good time to setup a review and brainstorm session to evaluate the past, investigate and think through the present and understand and plan for the future sustainable energy harvesting technologies.

CMOS Circuits for Piezoelectric Energy Harvesters

This monograph covers the fundamentals, fabrication,

testing, and modeling of ambient energy harvesters based on three main streams of energy-harvesting mechanisms: piezoelectrics, ferroelectrics, and pyroelectrics. It addresses their commercial and biomedical applications, as well as the latest research results. Graduate students, scientists, engineers, researchers, and those new to the field will find this book a handy and crucial reference because it provides a comprehensive perspective on the basic concepts and recent developments in this rapidly expanding field.

Power Harvesting Via Smart Materials

The development of renewable energy technologies (such as wind, solar, and biomass) has accelerated the establishment of a low-carbon society. This book provides a glimpse of some recent advancements in modelling, control, electrical generators and power converters, and social and political aspects of utilising these renewable sources of energy. It is aimed to provide some latest references for the readers who are interested in research work, energy policies, and social dimensions of renewable energy.

Electromagnetic Vibration Energy Harvesting Devices

Energy Harvesting Technologies provides a cohesive overview of the fundamentals and current developments in the field of energy harvesting. In a well-organized structure, this volume discusses basic principles for the design and fabrication of bulk and

MEMS based vibration energy systems, theory and design rules required for fabrication of efficient electronics, in addition to recent findings in thermoelectric energy harvesting systems. Combining leading research from both academia and industry onto a single platform, Energy Harvesting Technologies serves as an important reference for researchers and engineers involved with power sources, sensor networks and smart materials.

Energy Harvesting for Low-power Autonomous Devices and Systems

Self-powering of wireless sensors and wireless micro-devices become an important issue nowadays. Problems associated with chemical batteries such as limited life time and minimization restrictions can be solved by using the approach of energy harvesting. In this work, a way of vibration energy harvesting utilizing combined free/impact motion associated with electromagnetic transduction is proposed and studied. The study include impact with soft and hard end stops. A harvester with soft end stops shows a unique resonant behavior. However, A micro energy harvester with hard end stops (FHH) shows certain characteristics that make it more appropriate for human powered devices. It can harvest significant amount of energy from human motion during daily activities. The performance of FHH is analyzed and tested with human body motion at different body locations during different daily activities.

ICT - Energy Concepts for Energy

Efficiency and Sustainability

This Spotlight describes the configurations and performance optimization of piezoelectric energy harvesters. It presents in detail all of the relevant parameters to test the performance of piezoelectric and pyroelectric energy harvesters, including the latest measurement techniques. The specifications of state-of-the-art instruments are included. The text serves as a step-by-step instruction manual that will help readers to set up their own laboratory to design, characterize, and analyze the performance of energy harvesters. LabVIEW software is utilized to control instruments and acquire data from a piezoelectric energy harvester test station.

Low-frequency Electromagnetic Energy Harvesting

With its inclusion of the fundamentals, systems and applications, this reference provides readers with the basics of micro energy conversion along with expert knowledge on system electronics and real-life microdevices. The authors address different aspects of energy harvesting at the micro scale with a focus on miniaturized and microfabricated devices. Along the way they provide an overview of the field by compiling knowledge on the design, materials development, device realization and aspects of system integration, covering emerging technologies, as well as applications in power management, energy storage, medicine and low-power system electronics. In addition, they survey the energy harvesting

principles based on chemical, thermal, mechanical, as well as hybrid and nanotechnology approaches. In unparalleled detail this volume presents the complete picture -- and a peek into the future -- of micro-powered microsystems.

Energy Scavenging for Wireless Sensor Networks

The transformation of vibrations into electric energy through the use of piezoelectric devices is an exciting and rapidly developing area of research with a widening range of applications constantly materialising. With Piezoelectric Energy Harvesting, world-leading researchers provide a timely and comprehensive coverage of the electromechanical modelling and applications of piezoelectric energy harvesters. They present principal modelling approaches, synthesizing fundamental material related to mechanical, aerospace, civil, electrical and materials engineering disciplines for vibration-based energy harvesting using piezoelectric transduction. Piezoelectric Energy Harvesting provides the first comprehensive treatment of distributed-parameter electromechanical modelling for piezoelectric energy harvesting with extensive case studies including experimental validations, and is the first book to address modelling of various forms of excitation in piezoelectric energy harvesting, ranging from airflow excitation to moving loads, thus ensuring its relevance to engineers in fields as disparate as aerospace engineering and civil engineering. Coverage includes: Analytical and approximate

analytical distributed-parameter electromechanical models with illustrative theoretical case studies as well as extensive experimental validations Several problems of piezoelectric energy harvesting ranging from simple harmonic excitation to random vibrations Details of introducing and modelling piezoelectric coupling for various problems Modelling and exploiting nonlinear dynamics for performance enhancement, supported with experimental verifications Applications ranging from moving load excitation of slender bridges to airflow excitation of aeroelastic sections A review of standard nonlinear energy harvesting circuits with modelling aspects.

Electromagnetic Vibration Energy Harvesting Devices

As it was already seen in the first volume of the present book, its guideline is precisely the mathematical model of mechanics. The classical models which we refer to are in fact models based on the Newtonian model of mechanics, on its five principles, i. e. : the inertia, the forces action, the action and reaction, the parallelogram and the initial conditions principle, respectively. Other models, e. g. , the model of attraction forces between the particles of a discrete mechanical system, are part of the considered Newtonian model. Kepler’s laws brilliantly verify this model in case of velocities much smaller than the light velocity in vacuum. The non-classical models are relativistic and quantic. Mechanics has as object of study mechanical systems. The first volume of this book dealt with particle dynamics. The present

one deals with discrete mechanical systems for particles in a number greater than the unity, as well as with continuous mechanical systems. We put in evidence the difference between these models, as well as the specificity of the corresponding studies; the generality of the proofs and of the corresponding computations yields a common form of the obtained mechanical results for both discrete and continuous systems. We mention the thoroughness by which the dynamics of the rigid solid with a fixed point has been presented. The discrete or continuous mechanical systems can be non-deformable (e. g.

Frequency Analysis of Vibration Energy Harvesting Systems

Electromagnetic vibration transducers are seen as an effective way of harvesting ambient energy for the supply of sensor monitoring systems. Different electromagnetic coupling architectures have been employed but no comprehensive comparison with respect to their output performance has been carried out up to now. Electromagnetic Vibration Energy Harvesting Devices introduces an optimization approach which is applied to determine optimal dimensions of the components (magnet, coil and back iron). Eight different commonly applied coupling architectures are investigated. The results show that correct dimensions are of great significance for maximizing the efficiency of the energy conversion. A comparison yields the architectures with the best output performance capability which should be preferably employed in applications. A prototype

development is used to demonstrate how the optimization calculations can be integrated into the design–flow. Electromagnetic Vibration Energy Harvesting Devices targets the designer of electromagnetic vibration transducers who wishes to have a greater in-depth understanding for maximizing the output performance.

Piezoelectricity

This book describes the fundamentals and principles of energy harvesting and provides the necessary theory and background to develop energy harvesting power supplies. It explains the overall system design and gives quantitative assumptions on environmental energy. It explains different system blocks for an energy harvesting power supply and the trade-offs. The text covers in detail different energy transducer technologies such as piezoelectric, electrodynamic, and thermoelectric generators and solar cells from the material to the component level and explains the appropriate power management circuits required in these systems. Furthermore, it describes and compares storage elements such as secondary batteries and supercapacitors to select the most appropriate one for the application. Besides power supplies that use ambient energy, the book presents systems that use electromagnetic fields in the radio frequency range. Finally, it discusses different application fields and presents examples of self-powered electronic systems to illustrate the content of the preceding chapters.

Mechatronics 2019: Recent Advances Towards Industry 4.0

Vibration energy harvesting devices have been widely used to power many electronic self-sustainable devices. The aim of this study is to introduce an alternative design to an existing electromagnetic energy harvesting devices to improve the power production of the unit. This thesis presents a multiple degree of freedom compared design and it has demonstrated higher power efficiency over a wider range of frequencies. The power outputs for both the previous single degree of freedom and the current designs are compared and the developed models are validated against their experimental values. Finally, the numerical model is used to find an optimal arrangement to produce the maximum power for the unit.

Advances in Mechanism and Machine Science

This work addresses issues in energy harvesting that have plagued the potential use of harvesting through the piezoelectric effect at the MEMS scale. Effective energy harvesting devices typically consist of a cantilever beam substrate coated with a thin layer of piezoceramic material and fixed with a tip mass tuned to resonant at the dominant frequency of the ambient vibration. The fundamental natural frequency of a beam increases as its length decreases, so that at the MEMS scale the resonance condition occurs orders of magnitude higher than ambient vibration frequencies

rendering the harvester ineffective. Here we study two new geometries for MEMS scale cantilever harvesters. The zigzag and spiral geometries have low fundamental frequencies which can be tuned to the ambient vibrations. The second issue in energy harvesting is the frequency sensitivity of the linear vibration harvesters. A nonlinear hybrid energy harvester is presented that has a wide frequency bandwidth and large power output. Finally, linear and nonlinear energy harvesting devices are designed for powering the cardiovascular pacemakers using the vibrations in the chest area induced by the heartbeats. The mechanical and electromechanical vibrations of the zigzag structure are analytically modeled, verified with Rayleigh's method, and validated with experiments. An analytical model of coupled bending torsional vibrations of spiral structure is presented. A novel approximation method is developed for analyzing the electromechanical vibrations of energy harvesting devices. The unified approximation method is effective for linear, nonlinear mono-stable, and nonlinear bi-stable energy harvesting. It can also be utilized for piezoelectric, electromagnetic or iii hybrid energy harvesters. The approximation method accurately approximates the effect of energy harvesting on vibrations of energy harvester with changes in damping ratio and excitation frequency. Experimental investigations are performed to verify the analytical model of the nonlinear hybrid energy harvester. A detailed experimental parametric study of the nonlinear hybrid design is also performed. Linear and nonlinear energy harvesting devices have been designed that can generate sufficient amounts of power from the

heartbeat induced vibrations. The nonlinear devices are effective over a wide range of heart rate.

The Digital Signal Processing Handbook

This thesis outlines the design of a prototype electromagnetic induction vibration energy harvesting device for use in a downhole environment. First order models of the necessary components for a generic vibration energy harvester are presented and used to predict the most sensitive parameters for the design of energy harvesting systems. A subset of the design tools created in MATLAB and Excel for vibration energy harvester design and first order optimization is introduced and used to aid in the design of an energy harvester specific to the downhole environment. The manufacture of a prototype design is documented and recommendations for future manufacturing processes are given. The prototype is then tested against the models. Based on the results, final conclusions and recommendations for future refinements are made, and other applications are suggested.

Downhole Vibration Sensing by Vibration Energy Harvesting

Energy Harvesting for Wireless Sensor Networks

Kinetic energy harvesting converts movement or vibrations into electrical energy, enables battery free

operation of wireless sensors and autonomous devices and facilitates their placement in locations where replacing a battery is not feasible or attractive. This book provides an introduction to operating principles and design methods of modern kinetic energy harvesting systems and explains the implications of harvested power on autonomous electronic systems design. It describes power conditioning circuits that maximize available energy and electronic systems design strategies that minimize power consumption and enable operation. The principles discussed in the book will be supported by real case studies such as battery-less monitoring sensors at water waste processing plants, embedded battery-less sensors in automotive electronics and sensor-networks built with ultra-low power wireless nodes suitable for battery-less applications.

Sustainable Energy Harvesting Technologies

The vast reduction in size and power consumption of CMOS circuitry has led to a large research effort based around the vision of wireless sensor networks. The proposed networks will be comprised of thousands of small wireless nodes that operate in a multi-hop fashion, replacing long transmission distances with many low power, low cost wireless devices. The result will be the creation of an intelligent environment responding to its inhabitants and ambient conditions. Wireless devices currently being designed and built for use in such environments typically run on batteries. However, as the networks

increase in number and the devices decrease in size, the replacement of depleted batteries will not be practical. The cost of replacing batteries in a few devices that make up a small network about once per year is modest. However, the cost of replacing thousands of devices in a single building annually, some of which are in areas difficult to access, is simply not practical. Another approach would be to use a battery that is large enough to last the entire lifetime of the wireless sensor device. However, a battery large enough to last the lifetime of the device would dominate the overall system size and cost, and thus is not very attractive. Alternative methods of powering the devices that will make up the wireless networks are desperately needed.

Transformer and Inductor Design Handbook, Third Edition

"This book is an introductory text describing methods of harvesting electrical energy from mechanical potential and kinetic energy. The book focuses on the methods of transferring mechanical energy to energy conversion transducers of various types, including piezoelectric, electromagnetic, electrostatic, and magnetostrictive transducers. Methods that have been developed for collecting, conditioning, and delivering the generated electrical energy to a load, as well as their potential use as self-powered sensors are described. The book should be of interest to those who want to know the potentials as well as shortcomings of energy harvesting technology. The book is particularly useful for energy harvesting

system designers as it provides a systematic approach to the selection of the proper transduction mechanisms and methods of interfacing with a host system and electrical energy collection and conditioning options. An extensive bibliography is provided to direct the reader to appropriate references for detailed material not included in the book"--