Energy Harvesting Autonomous Sensor Systems Design Analysis And Practical Implementation

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.

This book discusses in detail the CMOS implementation of energy harvesting. The authors describe an integrated, indoor light energy harvesting system, based on a controller circuit that dynamically and automatically adjusts its operation to meet the actual light circumstances of the environment where the system is placed. The system is intended to power a sensor node, enabling an autonomous wireless sensor network (WSN). Although designed to cope with indoor light levels, the system is also able to work with higher levels, making it an all-round light energy harvesting system. The discussion includes experimental data obtained from an integrated manufactured prototype, which in conjunction with a photovoltaic (PV) cell, serves as a proof of concept of the desired energy harvesting system.

The United States has jurisdiction over 3.4 million square miles of ocean in its exclusive economic zone, a size exceeding the combined land area of the 50 states. This expansive marine area represents a prime national domain for activities such as maritime transportation, national security, energy and mineral extraction, fisheries and aquaculture, and tourism and recreation. However, it also carries with it the threat of damaging and outbreaks of waterborne pathogens. The 2010 Gulf of Mexico Deepwater Horizon oil spill and the 2011 Japanese earthquake and tsunami are vivid reminders that ocean activities and processes have direct human implications both nationally and worldwide, understanding of the ocean system is still incomplete, and ocean research infrastructure is needed to support both fundamental research and societal priorities. Given current struggles to maintain, operate, and upgrade major infrastructure elements while maintaining a robust research portfolio, a strategic plan is needed for future investments to ensure that new facilities provide the greatest value, least redundancy, and highest efficiency in terms of operation and flexibility to incorporate new technological advances. Critical Infrastructure for Ocean Research and Societal Needs in 2030 identifies major research questions anticipated to be at the forefront of ocean science in 2030 based on national and international assessments, input from the worldwide scientific community, and ongoing research planning activities. This report defines categories of infrastructure that should be included in planning for the nation's ocean research infrastructure of 2030 and that will be required to answer the major research questions of the future. Critical Infrastructure for Ocean Research and Societal Needs in 2030 provides advice on the criteria and

processes that could be used to set priorities for the development of new ocean infrastructure or replacement of existing facilities. In addition, this report recommends ways in which the federal agencies can maximize the value of investments in ocean infrastructure.

This proceedings book emphasizes adopting artificial intelligence-based and sustainable energy efficiency integrated with clear objectives, to involve researchers, students, and specialists in their development and implementation adequately in achieving objectives. The integration of artificial intelligence into renewable energetic systems would allow the rapid development of a knowledge-based economy suitable to the energy transition, while fully integrating the renewables into the global economy. This is how artificial intelligence has hand in by conceptualizing this transition and above all by saving time. The knowledge economy is valuated within the smart cities, which are fast becoming the favorite places where the energy transition will take place efficiently and intelligently by implementing integrated approaches to energy saving and energy supply and integrated urban approaches that go beyond individual interventions in buildings or transport modes using information and communication technologies.

Principles, Modeling and Applications

IoT Architectures, Models, and Platforms for Smart City Applications

Concepts, Methodologies, Tools, and Applications

Smart Materials in Structural Health Monitoring, Control and Biomechanics

On-Demand Energy Harvesting Techniques - a System Level Perspective

Energy Harvesting Autonomous Sensor Systems

In recent years, energy harvesting has been generating great interests among researchers, scientists and engineers alike. One of the major reasons for this increased interest sterns from the desire to have autonomous perpetual power supplies for remote monitoring sensor nodes utilizing some of the already available and otherwise wasted energy in the environment in a very innovative and useful way (and at the same time, maintaining a green environment). Scientists and engineers are constantly looking for ways of obtaining continuous and uninterrupted data from several points of interests especially remote or dangerous locations, using sensors coupled with RF transceivers, without the need of ever replacing or recharging the batteries that power these devices. This is now made possible through energy harvesting technologies which serve as suitable power supply substitutes, in many cases, for low power devices. With the proliferation of wireless energy in the environment through different radio frequency bands as well as natural sources like solar, wind and heat energy, it has become a desirable thing to take advantage of their availability by harvesting and converting them to useful

electrical energy forms. The energy so harnessed or harvested could then be utilized in sensor nodes. Now, since these energy sources fluctuate from time to time, and from place to place, there is the need to have a form of energy accumulation, conversion, conditioning and storage. The stored energy would then be reconverted and used by the sensors nodes and/or RF transceivers when needed. The process through which this is done is referred to as energy management. In this research work, many types of energy harvesting transducers were explored including - solar, thermal, electromagnetic and piezo/vibration. A proof of concept approach for an on-demand electromagnetic power generator is then presented towards the end. While most, if not all, of the energy harvesting techniques discussed needed some time to accumulate enough charge to operate their respective systems, the on-demand energy harvester makes energy available as at and when needed. In summary, a system level design is presented with suggested future research works.

"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"--

Civil infrastructure is the backbone of modern society, and maintaining said infrastructure is critical in maintaining healthy society. Wireless smart sensors (WSSs) provide a means to effectively monitor the performance of buildings and bridges to improve maintenance practices, minimize the costs of repair, and improve public safety through a

process called structural health monitoring (SHM). WSSs, traditionally powered by batteries, are limited in the length of time they can operate autonomously. The frequent need to change batteries in the networks can drive up maintenance costs and diminish the advantage first realized with WSSs. Efforts have been made to minimize the power consumption of WSSs operating in SHM networks, but there have been a limited number of new power supply options, such as energy harvesting, used in full-scale SHM applications. This research develops a solar energy harvesting system to provide power to Imote2 WSS platform and increase the long-term autonomy of wireless smart sensor networks (WSSNs). The approach is validated on a cable stayed bridge in South Korea. Additionally, software enhancements are introduced to allow sensor data to be stored in non-volatile memory, potentially further enhancing the efficacy of WSSNs. This research has resulted in greater overall autonomy of WSSNs.

This book investigates several non-resonant inductive harvester architectures in order to find the magnet coil arrangement that generates the largest power output. The book is useful as a step-by-step guide for readers

unfamiliar with this form of energy harvesting, but who want to build their own system models to calculate the magnet motion and, from that, the power generation available for body-worn sensor systems. The detailed description of system model development will greatly facilitate experimental work with the aim of fabricating the design with the highest predicted power output. Based on the simulated optimal geometry, fabricated devices achieve an average power output of up to 43 mW during walking, an amount of power that can supply modern low-power, body-worn systems. Experiments were also carried out in industrial applications with power outputs up to 15 mW. In sum, researchers and engineers will find a step-by-step introduction to inductive harvesting and its modeling aspects for achieving optimal harvester designs in an efficient manner.

Innovative Energy Harvesting Technology for Wireless Bridge Monitoring Systems

Autonomous Sensor Networks

Artificial Intelligence and Renewables Towards an Energy Transition

Critical Infrastructure for Ocean Research and Societal Needs in 2030

Introducing Energy Harvesting to Sensor Networks

Fundamentals of Wireless Sensor Networks

Energy Harvesting Autonomous Sensor Systems: Design, Analysis, and Practical Implementation provides a wide range of coverage of various energy harvesting techniques to enable the development of a truly self-autonomous and sustainable energy harvesting wireless sensor network (EH-WSN). It supplies a practical overview of the entire EH-WSN system from energy source all the way to energy usage by wireless sensor nodes/network. After an in-depth review of existing energy harvesting research thus far, the book focuses on: Outlines two wind energy harvesting (WEH) approaches, one using a wind turbine generator and one a piezoelectric wind energy harvester Covers thermal energy harvesting (TEH) from ambient heat sources with low temperature differences Presents two types of piezoelectric-based vibration energy harvesting systems to harvest impact or impulse forces from a human pressing a button or switch action Examines hybrid energy harvesting approaches that augment the reliability of the wireless sensor node's operation Discusses a hybrid wind and solar energy harvesting scheme to simultaneously use both energy sources and therefore extend the lifetime of the wireless sensor node

Explores a hybrid of indoor ambient light and TEH scheme that uses only one power management circuit to condition the combined output power harvested from both energy sources Although the author focuses on small-scale energy harvesting, the systems discussed can be upsized to large-scale renewable energy harvesting systems. The book goes beyond theory to explore practical applications that not only solve real-life energy issues but pave the way for future work in this area.

"Condition monitoring in electrical power networks can reduce maintenance costs, improve supply reliability and provide a real-time measurement of equipment operating conditions. For example, around a transformer we need to control parameters like KV, tap position, temperature of the transformer, oil temperature, buck trip, buck alarm, oil temperature trip, winding temperature alarm, auto tap position control etc. However, wiring monitoring sensors in a substation environment or on a power line and around High Voltage (HV) devices can be very expensive. Using Wireless Sensor Networks (WSNs) would reduce installation costs. Nonetheless, sensors would eventually run out of energy. Another factor to consider is that changing the

batteries of sensors located around HV devices can be costly, inconvenient and could potentially involve high personal safety risks. Consequently, for the purpose of condition monitoring, providing an autonomous WSN is of utmost importance. An autonomous WSN eliminates the problem of replacing batteries or recharging them manually. Enabling nodes in the network to harvest energy from their ambient environment may provide us with a self-powering WSN. Fortunately, a substation area is a rich environment for energy harvesting purposes. However, not all the monitoring sensors are necessarily close enough to HV terminals to take advantage of energy harvesting potential.This thesis studies the possibility of deploying an autonomous wireless sensor network in a substation environment. To this end, a hierarchical energy-harvesting model is proposed in which energy is scavenged in two levels. In the first step, energy is scavenged using harvesters that are located close to high voltage terminals. Then a portion of the scavenged energy will be distributed to nearby sensor nodes by radiating radio frequency signals to them. The hierarchical aspect of our model allows us to deal with the non-uniform distribution of the energy harvesting

resources.The main goal of this thesis is to evaluate and optimize the performance of the proposed hierarchical energy-harvesting model. To this end, we have studied our system through mathematical analysis and computer simulations. %Our analysis allows us to predict the outage probability for a system, consisting of a number of sensors and with different initial settings. Therefore, the involved parameters can be adjusted to deliver the targeted performance. We also have proposed power allocation techniques to maximize the efficiency of our autonomous WSN.In this work we show that despite the wasteful nature of wireless transfer of energy, a self-sustainable wireless sensor network in a substation area can be accomplished"--

Within the past 15 years, significant advances in semiconductor integrated circuits (ICs) have reduced power consumption requirements such that mechanisms of transducing various forms of ambient energy for providing autonomous power are a viable technology. The field of energy harvesting has grown immensely as new solutions for developing self-sustaining wireless sensor networks for applications such as structural health monitoring (SHM), precision viticulture,

and biometric wearable devices are continually investigated. Due to the wide variety of energy transduction methods and the inherent multidisciplinary nature of energy harvesting, a systematic paradigm for the capture and use of ambient energy is presented. The research outlined in this dissertation covers two energy transduction mechanisms : electrochemical energy harvesting, and vibration energy harvesting. The first project presented details the modeling, development and testing of a novel cement sea-water battery (C-SWB) and a complimentary low-power sensor node designed for long-term marine infrastructure health monitoring. The second project investigates analytically and experimentally the augmented broadband vibration energy capture of a modulated inertial generator (MIG). Closed-form analytical expressions of interacting electromagnetic dipole moments are derived and used as a nonlinear control parameter to modulate the response of an inertial generator to expand the resonant frequency response spectrum.

A thorough treatment of the principles, applications and system integration of energy harvesting technology.

Energy Harvesting for Wearable Sensor

Systems

Encyclopedia of Wireless Networks

Autonomous Wireless Sensor Network in a Substation Area Using Energy Harvesting and Wireless Transfer of Energy

Architectures, Design, Modeling and Optimization

Algorithms, Methodologies, Technologies and Perspectives

Smart Sensor Systems

This volume surveys recent research on autonomous sensor networks from the perspective of enabling technologies that support medical, environmental and military applications. State of the art, as well as emerging concepts in wireless sensor networks, body area networks and ambient assisted living introduce the reader to the field, while subsequent chapters deal in depth with established and related technologies, which render their implementation possible. These range from smart textiles and printed electronic devices to implanted devices and specialized packaging, including the most relevant technological features. The last four chapters are devoted to customization, implementation difficulties and outlook for these technologies in specific applications.

"Smart Materials in Structural Health Monitoring, Control and Biomechanics" presents the latest developments in structural health monitoring, vibration control and biomechanics using smart materials. The book mainly focuses on piezoelectric, fibre optic and ionic polymer metal composite materials. It introduces concepts from the very basics and leads to advanced modelling (analytical/ numerical), practical aspects (including software/ hardware issues) and case studies spanning civil, mechanical and aerospace structures, including bridges, rocks and underground structures. This book is intended for

practicing engineers, researchers from academic and R&D institutions and postgraduate students in the fields of smart materials and structures, structural health monitoring, vibration control and biomedical engineering. Professor Chee-Kiong Soh and Associate Professor Yaowen Yang both work at the School of Civil and Environmental Engineering, Nanyang Technological University, Singapore. Dr. Suresh Bhalla is an Associate Professor at the Department of Civil Engineering, Indian Institute of Technology Delhi, India.

Collecting and processing data is a necessary aspect of living in a technologically advanced society. Whether it?s monitoring events, controlling different variables, or using decision-making applications, it is important to have a system that is both inexpensive and capable of coping with high amounts of data. As the application of these networks becomes more common, it becomes imperative to evaluate their effectiveness as well as other opportunities for possible implementation in the future. Sensor Technology: Concepts, Methodologies, Tools, and Applications is a vital reference source that brings together new ways to process and monitor data and to put it to work in everything from intelligent transportation systems to healthcare to multimedia applications. It also provides inclusive coverage on the processing and applications of wireless communication, sensor networks, and mobile computing. Highlighting a range of topics such as internet of things, signal processing hardware, and wireless sensor technologies, this multi-volume book is ideally designed for research and development engineers, IT specialists, developers, graduate students, academics, and researchers.

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.

Wireless Power Transmission for Sustainable Electronics

An Integral Approach with Focus on Solar and RF Energy Harvesting

CMOS Indoor Light Energy Harvesting System for Wireless Sensing Applications

Energy Harvesting Technologies

Powering Autonomous Sensors

Advances in Energy Harvesting Methods

This book focuses on the Internet of Everything and related fields. The Internet of Everything adds connectivity and intelligence to just about every device, giving it special functions. The book provides a common platform for integrating information from heterogeneous sources. However, this can be quite reductive, as the Internet of Everything provides links not only among things, but also data, people, and business processes. The evolution of current sensor and device networks, with strong interactions between people and social environments, will have a dramatic impact on everything from city planning, first responders, the military and health. Such a shared ecosystem will allow for the interaction between data, sensor inputs and heterogeneous systems. Semantics is a fundamental component of this since semantic technologies are able to provide the necessary bridge between different data representations, and to solve terminology incongruence. Integrating data from distributed devices, sensor networks, social networks and biomedical instruments requires, first of all, the systematization of the current state of the art in such fields. Then, it is necessary to identify a common action thread to actually merge and homogenize standards and techniques applied in such a heterogeneous field. The exact requirements of an Internet of Everything environment need to be precisely identified and formally expressed, and finally, the role of modern computing paradigms, such as Cloud and Fog Computing, needs to be assessed with respect to the requirements expressed by an Internet of Everything ecosystem.

The principle of energy harvesting, i. e. gleaning of extremely small amounts of energy from the environment, has been around for a long time. For technical reasons, the idea of operating a wireless link, commercially, with energy from the environment was to date only possible with solar

cells, and outdoors where there is sufficient light. EnOcean is the first company to offer commercial solutions for operating wireless links in low-light indoor surroundings, or by energy sources that are an alternate to light. In this paper we will discuss two application scenarios for energy-autonomous sensor/actor networks with partly contrary requirements. The first application scenario is typical for e.g. building automation or environmental monitoring, where the wirelessly operated sensors are distributed over a widespread area and only a few measurement values are generated in a moderate time interval. Modern fabrication facilities with highly flexible manufacturing cells or highly dynamic processes in the military environment, where clusters of sensors and actuators have to be read-out and controlled in a limited space under stringent real-time limitations stand for the second application scenario. We will describe the current status of technology, show measurement results, tell about experiences already made in the field and give a prospective view of possible future developments. Although primarily developed for new application scenarios in building systems engineering, household, logistics, environmental protection and production automation wireless sensor/actor networks based on EnOcean technology can also be tailored to military needs for future air, ground and naval vehicle capabilities.

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.

Developing countries are persistently looking for efficient and cost-effective methods for transforming their communities into smart cities. Unfortunately, energy crises have increased in these regions due to a lack of awareness and proper utilization of technological methods. These communities must explore and implement innovative solutions in order to enhance citizen enrollment, quality of government, and city intelligence. IoT Architectures, Models, and Platforms for Smart City Applications provides emerging research exploring the theoretical and practical aspects of transforming cities into intelligent systems using IoT-based design models and sustainable development projects. This publication looks at how cities can be built as smart cities within limited resources and existing advanced technologies. Featuring coverage on a broad range of topics such as cloud computing, human machine interface, and ad hoc networks, this book is ideally designed for urban planners, engineers, IT specialists, computer engineering students, research scientists, academicians, technology developers, policymakers, researchers, and designers seeking current research on smart applications within urban development.

Rechargeable Sensor Networks: Technology, Theory, and Application

Energy Harvesting Paradigms for Autonomously-Powered

Sensor Networks
Proceedings of ICAETT 2020
Internet of Everything
Theory and Practice
Sensors

Wireless networking technologies are witnessed to become the integral part of industry, business, entertainment and daily life. Encyclopedia of Wireless Networks is expected to provide comprehensive references to key concepts of wireless networks, including research results of historical significance, areas of current interests, and growing directions in the future wireless networks. It can serve as a valuable and authoritative literature for students, researchers, engineers, and practitioners who need a quick reference to the subjects of wireless network technology and its relevant applications. Areas covered: 5G Network | Editors: Rahim Tafazolli, Rose Hu Ad hoc Network | Editor: Cheng Li Big Data for Networking | Editor: Song Guo Cellular Network, 2G/3G Network, 4G/LTE Network | Editor: Hsiao-hwa Chen Cognitive Radio Network | Editor: Ning Zhang Cooperative Communications | Editor: Kaoru Ota Cyber Physical Systems | Editor: Shiyan Hu Data Center Network | Editor: Lei Lei Delay Tolerant and Opportunistic Network | Editor: Yuanguo Bi Equalization, Synchronization and Channel Estimation | Editor: Yingying Chen Future Network Architecture | Editor: Wei Quan Game Theory in Wireless Network |

Editor: Dusit Niyato Interference Characterization and Mitigation | Editor: Lin Cai Internet of Things | Editors: Xiuzhen Cheng, Wei Cheng Internet of Things and its Applications | Editor: Phone Lin Interworking Heterogeneous Wireless Network | Editor: Ping Wang Medium Access Control | Editors: Hassan Omar, Qiang Ye Millimeter-wave Communications | Editor: Ming Xiao MIMO-based Network | Editor: Prof. Wei Zhang Mobility Management and Models | Editors: Sandra Cespedes, Sangheon Pack Molecular, Biological and Multi-scale Communications | Editor: Adam Noel Network Economics and pricing | Editors: Jianwei Huang, Yuan Luo Network Forensics and surveillance, Fault Tolerance and Reliability | Editor: Hongwei Li Network Measurement and Virtualization | Editor: Yusheng Ji Quality of Service, Quality of Experience and Quality of Protection | Editors: Rui Luis Aguiar, Yu Cheng Resource Allocation and Management | Editors: Junshan Zhang, Nan Cheng Routing and Multi-cast, Router and Switch Design | Editor: Richard Yu Scaling Laws and Fundamental Limits | Editor: Ning Lu Security, Privacy and Trust | Editor: Kui Ren Short Range Communications, RFID and NFC | Editor: Zhiguo Shi Smart Grid Communications | Editor: Vincent W. S. Wong Vehicular Network | Editors: Lian Zhao, Qing Yang Video Streaming | Editor: Zhi Liu Wireless Body Area Network and e-healthcare | Editor: Honggang Wang Wireless Security | Editors: Haojin Zhu, Jian Shen Wireless Sensor Network

| Editors: Jiming Chen, Ruilong Deng WLAN and OFDM | Editor: Xianbin Wang
Providing a detailed overview of the fundamentals and latestdevelopments in the field of energy autonomous microsystems, thisbook delivers an in-depth study of the applications in the fieldsof health and usage monitoring in aeronautics, medical implants,and home automation, drawing out the main specifications on suchsystems. Introductory information on photovoltaic, thermal andmechanical energy harvesting, and conversion, is given, along withthe latest results in these fields. This book also provides a stateof the art of ultra-low power sensor interfaces, digital signalprocessing and wireless communications. In addition, energyoptimizations at the sensor node and sensors network levels arediscussed, thus completing this overview. This book details the challenges and latest techniques available toreaders who are interested in this field. A major strength of thisbook is that the first three chapters are application orientatedand thus, by setting the landscape, introduce the technicalchapters. There is also a good balance between the technicalapplication, covering all the system-related aspects and, withineach chapter, details on the physics, materials and technologiesassociated with electronics. Contents Introduction. Introduction to Energy AutonomousMicro& and Nano Systems and Presentation of Contributions,Marc Belleville

and Cyril Condemine. 1. Sensors at the Core of Building Control, Gilles Chabanis,Laurent Chiesi, Hynek Raisigel,& Isabelle Ressejac andVéronique Boutin. 2. Toward Energy Autonomous MedicalImplants, Raymond Campagnolo andDaniel Kroiss. 3. Energy Autonomous Systems in Aeronautic Applications, ThomasBecker, Jirka Klaue and Martin Kluge. 4. Energy Harvesting by Photovoltaic Effect, EmmanuelleRouvière, Simon Perraud, Cyril Condemine and& GuyWaltisperger. 5. Mechanical Energy Harvesting, Ghislain Despesse, Jean JacquesChaillout,& Sébastien Boisseau and ClaireJean-Mistral. 6. Thermal Energy Harvesting, Tristan Caroff, EmmanuelleRouvière and Jérôme Willemin. 7. Lithium Micro-Batteries, Raphaël Salot. 8. Ultra-Low-Power Sensors, Pascal Nouet, Norbert Dumas, LaurentLatorre and& Frédérick Mailly. 9. Ultra-Low-Power Signal Processing in Autonomous Systems,Christian Piguet. 10. Ultra-Low-Power Radio Frequency Communications and Protocols,Eric Mercier. 11. Energy Management in an Autonomous Microsystem,Jean-Frédéric Christmann, Edith Beigne, Cyril Condemine,Jérôme Willemin and Christian Piguet. 12. Optimizing Energy Efficiency of & Sensor Networks,Olivier Sentieys and Olivier Berder.

This second book by the author on WSNs focuses on the concepts of energy, and energy harvesting and management techniques. Definitions and terminologies are made clear

without leaning on the relaxing assumption that they are already known or easily reachable, the reader is not to be diverted from the main course. Neatly drawn figures assist in viewing and imagining the offered topics. To make energy related topics felt and seen, the adopted technologies as well as their manufacturers are presented in details. With such a depth, this book is intended for a wide audience, it is meant to be helper and motivator, for the senior undergraduates, postgraduates, researchers, and practitioners; concepts and energy related applications are laid out, research and practical issues are backed by appropriate literature, and new trends are put under focus. For senior undergraduate students, it familiarizes with conceptual foundations and practical projects implementations. Also, it is intended for graduate students working on their thesis and in need of specific knowledge on WSNs and the related energy harvesting and management techniques. Moreover, it is targeting researchers and practitioners interested in features and applications of WSNs, and on the available energy harvesting and management projects and testbeds. Exercises at the end of each chapter are not just questions and answers; they are not limited to recapitulate ideas. Their design objective is not bound to be a methodical review of the provided concepts, but rather as a motivator for lot more of searching, finding, and comparing beyond what

has been presented in the book.
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.
Micro Energy Harvesting
Energy Harvesting and Management for Research and Industry
Proceedings of the First National Conference on Sensors, Rome 15-17 February, 2012
Technologies, Systems, and Challenges
Sensor Technology: Concepts, Methodologies, Tools, and Applications
Collective Sensing Strategies for Analytical Purposes
This book constitutes the proceedings of the 2nd International Conference on Advances in Emerging Trends and Technologies (ICAETT 2020), held in Riobamba, Ecuador, on 26–30 October 2019, proudly organized by Facultad de Informática y Electrónica (FIE) at Escuela Superior Politécnica de Chimborazo and supported by GDEON.

ICAETT 2020 brings together top researchers and practitioners working in different domains of computer science to share their expertise and to discuss future developments and potential collaborations. Presenting high-quality, peer-reviewed papers, the book discusses the following topics: Communicationse-Government and e-Participatione-LearningElectronicIntelligent SystemsMachine VisionSecurityTechnology Trends

With contributions from an internationally-renowned group ofexperts, this book uses a multidisciplinary approach to reviewrecent developments in the field of smart sensor systems, coveringimportant system and design aspects. It examines topics overthe whole range of sensor technology from the theory andconstraints of basic elements, physics and electronics, up to thelevel of application-orientated issues. Developed as a complementary volume to 'Smart SensorSystems' (Wiley 2008), which introduces the basics of smartsensor systems, this volume focuses on emerging sensingtechnologies and applications, including: State-of-the-art techniques for designing smart sensors andsmart sensor systems, including measurement techniques at systemlevel, such as dynamic error correction, calibration,self-calibration and trimming. Circuit design for sensor systems, such as the design ofprecision instrumentation amplifiers. Impedance sensors, and the associated measurement techniquesand electronics, that measure electrical characteristics to derivephysical and biomedical parameters, such as blood viscosity orgrowth of micro-organisms. Complete sensor systems-on-a-chip, such as CMOS optical imagersand microarrays for DNA detection, and the associated circuit andmicro-fabrication techniques. Vibratory gyroscopes and the associated electronics, employingmechanical and electrical signal amplification to enable low-powerangular-rate sensing. Implantable smart sensors for neural interfacing in

bio-medicalapplications. Smart combinations of energy harvesters and energy-storagedevices for autonomous wireless sensors. Smart Sensor Systems: Emerging Technologies and Applicationswill greatly benefit final-year undergraduate and postgraduatestudents in the areas of electrical, mechanical and chemicalengineering, and physics. Professional engineers and researchers inthe microelectronics industry, including microsystem developers,will also find this a thorough and useful volume.
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 is a promising and evolving field of research capable of supplying power to systems in a broad range of applications. In particular, the ability to gather energy directly from the environment without human intervention

makes energy harvesting an excellent option for powering autonomous sensors in remote or hazardous locations. This dissertation examines the possibility of using energy harvesting in new and innovative ways to power wireless sensor nodes placed in the substructures of highway bridges for structural health monitoring. Estimates for power requirements are established, using a wireless sensor node from National Instruments as an example system. Available power in a bridge environment is calculated for different energy sources, including solar radiation, wind, and vibration from traffic. Feasibility of using energy harvesting in such an application is addressed for both power availability and cost as compared with grid power or primary batteries. An in-depth functional analysis of existing energy-harvesting systems is also presented, with insights into where innovation would be most beneficial in future systems. Finally, the development of a suite of complementary energy-harvesting devices is described. Because conditions on bridges may vary, multiple solutions involving different energy domains are desired, with the end user able to select the harvester most appropriate for the specific installation. Concept generation techniques such as mind-mapping and 6-3-5 (C-Sketch) are used to produce a wide variety of concepts, from which several promising concept variants are selected. The continued development for one concept, which harvests vibration using piezoelectric materials, is described. Analytical modeling is presented for static and dynamic loading, as well as predicted power generation. Two proof-of-concept prototypes are built and tested in laboratory conditions. Through the development of this prototype, it is shown that the example wireless sensor node can successfully be powered through energy harvesting, and insights are shared concerning the situations where this and other energy harvesters would be most appropriate.

Design Considerations of Harvested-energy Management
High Performance Materials and Devices for High-Speed Electronic Systems
RF-Embedding of Energy-Autonomous Sensors and Actuators Into Wireless Sensor Networks
Wireless Sensor Networks
Energy Harvesting for Autonomous Systems
The Role of Energy Reservoirs in Distributed Computing

This book contains a selection of papers presented at the First National Conference on Sensors held in Rome 15-17 February 2011. The conference highlighted state-of-the-art results from both theoretical and applied research in the field of sensors and related technologies. This book presents material in an interdisciplinary approach, covering many aspects of the disciplines related to sensors, including physics, chemistry, materials science, biology and applications. · Provides a selection of the best papers from the First Italian National Conference on Sensors; · Covers a broad range of topics relating to sensors and microsystems, including physics, chemistry, materials science, biology and applications; · Offers interdisciplinary coverage, aimed at defining a common ground for sensors beyond the specific differences among the different particular implementation of sensors.

Autonomous sensors transmit data and power their electronics without using cables. They can be found in e.g. wireless sensor networks (WSNs) or remote

acquisition systems. Although primary batteries provide a simple design for powering autonomous sensors, they present several limitations such as limited capacity and power density, and difficulty in predicting their condition and state of charge. An alternative is to extract energy from the ambient (energy harvesting). However, the reduced dimensions of most autonomous sensors lead to a low level of available power from the energy transducer. Thus, efficient methods and circuits to manage and gather the energy are a must. An integral approach for powering autonomous sensors by considering both primary batteries and energy harvesters is presented. Two rather different forms of energy harvesting are also dealt with: optical (or solar) and radiofrequency (RF). Optical energy provides high energy density, especially outdoors, whereas RF remote powering is possibly the most feasible option for autonomous sensors embedded into the soil or within structures. Throughout different chapters, devices such as primary and secondary batteries, supercapacitors, and energy transducers are extensively reviewed. Then, circuits and methods found in the literature used to efficiently extract and gather the energy are presented. Finally, new proposals based on the authors' own research are analyzed and tested. Every chapter is written to be rather independent, with each incorporating the

relevant literature references. Powering Autonomous Sensors is intended for a wide audience working on or interested in the powering of autonomous sensors. Researchers and engineers can find a broad introduction to basic topics in this interesting and emerging area as well as further insights on the topics of solar and RF harvesting and of circuits and methods to maximize the power extracted from energy transducers.

The harvesting of energy from ambient energy sources to power electronic devices has been recognized as a promising solution to the issue of powering the ever-growing number of mobile devices around us. Key technologies in the rapidly growing field of energy harvesting focus on developing solutions to capture ambient energy surrounding the mobile devices and convert it into usable electrical energy for the purpose of recharging said devices. Achieving a sustainable network lifetime via battery-aware designs brings forth a new frontier for energy optimization techniques. These techniques had, in their early stages, resulted in the development of low-power hardware designs. Today, they have evolved into power-aware designs and even battery-aware designs. This book covers recent results in the field of rechargeable sensor networks, including technologies and protocol designs to enable harvesting energy from alternative energy sources

such as vibrations, temperature variations, wind, solar, and biochemical energy and passive human power. Contents:Wind Energy Harvesting for Recharging Wireless Sensor Nodes: Brief Review and a Case Study (Yen Kheng Tan, Dibin Zhu and Steve Beeby)Rechargeable Sensor Networks with Magnetic Resonant Coupling (Liguang Xie, Yi Shi, Y Thomas Hou, Wenjing Lou, Hanif D Sherali and Huaibei Zhou)Cross-Layer Resource Allocation in Energy-Harvesting Sensor Networks (Zhoujia Mao, C Emre Koksal and Ness B Shroff)Energy-Harvesting Technique and Management for Wireless Sensor Networks (Jianhui Zhang and Xiangyang Li)Information Capacity of an AWGN Channel Powered by an Energy-Harvesting Source (R Rajesh, P K Deekshith and Vinod Sharma)Energy Harvesting in Wireless Sensor Networks (Nathalie Mitton and Riaan Wolhuter)Topology Control for Wireless Sensor Networks and Ad Hoc Networks (Sunil Jardosh)An Evolutionary Game Approach for Rechargeable Sensor Networks (Majed Haddad, Eitan Altman, Dieter Fiems and Julien Gaillard)Marine Sediment Energy Harvesting for Sustainable Underwater Sensor Networks (Baikun Li, Lei Wang and Jun-Hong Cui)Wireless Rechargeable Sensor Networks in the Smart Grid (Melike Erol-Kantarci and Hussein T Mouftah)Energy-Harvesting Methods for Medical Devices (Pedro Dinis Gaspar, Virginie Felizardo and Nuno M Garcia)

Readership: Graduates, researchers, and professionals studying/dealing with networking, computer engineering, parallel computing, and electrical & electronic engineering.
Keywords:Rechargeable Sensor;Energy Harvesting Technology;Renewable Sensor NetworksKey Features:This book provides comprehensive coverage from hardware design, protocol design, to applications. This book provides very recent results. And this book has prominent contributorsWith the increasing deterioration of global warming, energy harvesting technologies as a green source of energy are of great interest to research community. For wireless networks especially wireless sensor networks, the introduction of energy harvesting technologies can address the challenge of energy constraint and obtain perpetual network operation. Although there are lots of existing publications on energy harvesting, most of them are journal and conference papers, which concentrate on specific research problems and do not provide a comprehensive overview and prerequisite preliminaries to understand the energy harvesting technologies. To the best of our knowledge, there are only a few books which are concerned with energy harvesting technologies. One main drawback of these books are that they all elaborate on the hardware design of energy harvesting

devices but neglect the impact of hardware design on the performance of overall networks which is also of great significance in practice. For example, the energy management subsystem should be designed to fulfill all the tasks without running out of energy, which is dependent on the available energy of each node and all the tasks of the whole networks. Hence, the algorithm and protocol optimization are as important as hardware design. But this was not elaborated in existing publications and motivates this book

In this review volume, the editors have included the state-of-the-art research and development in nano composites, and optical electronics written by experts in the field. In addition, it also covers applications for emerging technologies in High-Speed Electronics. In summary, topics covered in this volume includes various aspects of high performance materials and devices for implementing High-Speed Electronic systems.

Emerging Technologies and Applications

Solar Energy Harvesting and Software Enhancements for Autonomous Wireless Smart Sensor Networks

Proceedings of the Third National Conference on Sensors, February 23-25, 2016, Rome, Italy

Energy Autonomous Micro and Nano Systems

COST WiPE - IC1301

Electromagnetic Vibration Energy Harvesting

Devices

In this book, the authors describe the fundamental concepts and practical aspects of wireless sensor networks. The book provides a comprehensive view to this rapidly evolving field, including its many novel applications, ranging from protecting civil infrastructure to pervasive health monitoring. Using detailed examples and illustrations, this book provides an inside track on the current state of the technology. The book is divided into three parts. In Part I, several node architectures, applications and operating systems are discussed. In Part II, the basic architectural frameworks, including the key building blocks required for constructing large-scale, energy-efficient sensor networks are presented. In Part III, the challenges and approaches pertaining to local and global management strategies are presented – this includes topics on power management, sensor node localization, time synchronization, and security. At the end of each chapter, the authors provide practical exercises to help students strengthen their grip on the subject. There are more than 200 exercises altogether. Key Features: Offers a comprehensive introduction to the theoretical and practical concepts pertaining to wireless sensor networks Explains the constraints and challenges of wireless sensor network design; and discusses the most promising solutions Provides an in-depth treatment of the most critical technologies for sensor network communications, power management, security, and programming Reviews the latest research results in sensor network design, and demonstrates how the individual components fit together to build complex sensing systems

for a variety of application scenarios Includes an accompanying website containing solutions to exercises (http://www.wiley.com/go/dargie_fundamentals) This book serves as an introductory text to the field of wireless sensor networks at both graduate and advanced undergraduate level, but it will also appeal to researchers and practitioners wishing to learn about sensor network technologies and their application areas, including environmental monitoring, protection of civil infrastructure, health care, precision agriculture, traffic control, and homeland security.

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.

Provides a collection of works produced by COST Action IC1301 with the goal of achieving significant advances in the

field of wireless power transmission This book constitutes together information from COST Action IC1301, a group of academic and industry experts seeking to align research efforts in the field of wireless power transmission (WPT). It begins with a discussion of backscatter as a solution for Internet of Things (IoT) devices and goes on to describe ambient backscattering sensors that use FM broadcasting for low cost and low power wireless applications. The book also explores localization of passive RFID tags and augmented tags using nonlinearities of RFID chips. It concludes with a review of methods of electromagnetic characterization of textile materials for the development of wearable antennas. Wireless Power Transmission for Sustainable Electronics: COST WiPE - IC1301 covers textile-supported wireless energy transfer, and reviews methods for the electromagnetic characterization of textile materials for the development of wearable antennas. It also looks at: backscatter RFID sensor systems for remote health monitoring; simultaneous localization (of robots and objects) and mapping (SLAM); autonomous system of wireless power distribution for static and moving nodes of wireless sensor networks; and more. Presents techniques for smart beam-forming for "on demand" wireless power transmission (WPT) Discusses RF and microwave energy harvesting for space applications Describes miniaturized RFID transponders for object identification and sensing Wireless Power Transmission for Sustainable Electronics: COST WiPE - IC1301 is an excellent book for both graduate students and industry engineers involved in wireless communications and power

transfer, and sustainable materials for those fields.
This book gathers the best papers presented at the Third Italian National Conference on Sensors, held in Rome, Italy, from 23 to 25 February 2016. The book represents an invaluable and up-to-the-minute tool, providing an essential overview of recent findings, strategies and new directions in the area of sensor research. Further, it addresses various aspects based on the development of new chemical, physical or biological sensors, assembling and characterization, signal treatment and data handling. Lastly, the book applies electrochemical, optical and other detection strategies to relevant issues in the food and clinical environmental areas, as well as industry-oriented applications.
Inductive Architectures for the Swing Excitation of the Leg
Energy Harvesting Systems
Energy Harvesting
Advances in Emerging Trends and Technologies
Energy Harvesting for Low-power Autonomous Devices and Systems
Design, Analysis, and Practical Implementation
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.

The world already hosts more internet connected devices than people, and that ratio is only increasing. These devices seamlessly integrate with peoples lives to collect rich data and give immediate feedback about complex systems from business, health care, transportation, and security. As every aspect of global economies integrate distributed computing into their industrial systems and these systems benefit from rich datasets. Managing the power demands of these distributed computers will be paramount to ensure the continued operation of these networks, and is elegantly addressed by including local energy harvesting and storage on a per-node basis. By replacing non-rechargeable batteries with energy harvesting, wireless sensor nodes will increase their lifetimes by an order of magnitude. This work investigates the coupling of high power energy storage with energy harvest- ing technologies to power wireless sensor nodes; with sections covering device manufacturing, system integration, and mathematical modeling. First we consider the energy storage mechanism of supercapacitors and batteries, and identify favorable characteristics in both reservoir types. We then

discuss experimental methods used to manufacture high power supercapacitors in our labs. We go on to detail the integration of our fabricated devices with collaborating labs to create functional sensor node demonstrations. With the practical knowledge gained through in-lab manufacturing and system integration, we build mathematical models to aid in device and system design. First, we model the mechanism of energy storage in porous graphene supercapacitors to aid in component architecture optimization. We then model the operation of entire sensor nodes for the purpose of optimally sizing the energy harvesting and energy reservoir components. In consideration of deploying these sensor nodes in real-world environments, we model the operation of our energy harvesting and power management systems subject to spatially and temporally varying energy availability in order to understand sensor node reliability. Looking to the future, we see an opportunity for further research to implement machine learning algorithms to control the energy resources of distributed computing networks.

Using energy harvesting for powering autonomous sensor systems can meet the goal of perpetual operation. However, the uncertainty in system supply coupled with the size constraints presents challenges in design of such systems. To address these challenges,this thesis is concerned with effective management of harvested-energy for

matching supply and demand in order to operate perpetually with uniform performance. The thesis focuses on two fundamental design considerations in addressing these challenges: (i) managing variability of the energy harvesting source, and (ii) matching the demand with energy supply under the influence of non-ideal characteristics of the harvesting system. To address the problem of variability of energy source, the thesis focuses on effective prediction of harvested-energy. An effective approach for evaluating the accuracy of solar energy prediction algorithm is proposed and optimised values of prediction algorithm parameters are determined to minimise prediction error. The problem of achieving uniform performance under the supply variability is addressed by proposing a new prediction based energy management policy. The results of the proposed policy are compared with other recently reported policies and it is shown that the proposed policy achieves up to 41% lower variance in performance and 30% lower dead time of the system, which is important to achieve the goal of perpetual operation. To address the problem of effective matching of supply and demand, the thesis considers the design of photovoltaic energy harvesting supply and storage subsystem in terms of its component's non-ideal characteristics. The influence of these characteristics on supply and demand is identified using modeling of losses and

component interdependencies, and empirically validated using a reference system design. Using the proposed modeling, the performance of recently reported energy management policies is evaluated to show that these are ineffective in achieving the goal of perpetual operation, and optimisations are proposed to address this.

Piezoelectric Energy Harvesting

Manufacturing, Implementing, and Optimizing Energy Storage in Energy-autonomous Sensor Nodes