

ENERGY HARVESTING AUTONOMOUS SENSOR SYSTEMS

Design, Analysis, and Practical Implementation

Yen Kheng Tan



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Energy Harvesting Autonomous Sensor Systems Design Analysis And Practical Implementation

Dušan Vučković



Energy Harvesting Autonomous Sensor Systems Design Analysis And Practical Implementation:

Energy Harvesting Autonomous Sensor Systems Yen Kheng Tan, 2017-12-19 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

Energy Harvesting Autonomous Sensor Systems Yen Kheng Tan, 2013-01-29 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 **IoT Architectures, Models, and Platforms for Smart City Applications** Chowdhry, Bhawani Shankar, Shaikh, Faisal Karim, Mahoto, Naeem Ahmed, 2019-12-27 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 - Introducing Energy Harvesting To Sensor Networks Jiming Chen, Shibo He, Youxian Sun, 2014-01-28 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 **Transactions on Engineering Technologies** Sio-Iong Ao, Haeng Kon Kim, Xu Huang, Oscar Castillo, 2017-04-03 This volume contains selected revised and extended research articles written by prominent researchers who participated in the International MultiConference of Engineers and Computer Scientists 2016 held in Hong Kong 16 18 March 2016 Topics covered include engineering physics communications systems control theory automation engineering mathematics scientific computing electrical engineering and industrial applications The book showcases the tremendous advances in engineering technologies and applications and also serves as an excellent reference work for researchers and graduate students working on engineering technologies physical sciences and their applications **Artificial Intelligence and Renewables Towards an Energy Transition** Mustapha Hatti, 2020-12-17 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 valued 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

Advances in Emerging Trends and Technologies Miguel Botto-Tobar, Omar S. Gómez, Raúl Rosero Miranda, Angela Díaz Cadena, 2020-12-18 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

IoT for Sustainable Smart Cities and Society Joel J. P. C. Rodrigues, Parul Agarwal, Kavita Khanna, 2022-05-10 This book provides a sound theoretical base and an extensive practical expansion of smart sustainable cities and societies while also examining case studies in the area to help readers understand IoT driven solutions in smart cities The book covers fundamentals applications and challenges of IoT for sustainable smart cities and society With a good understanding of IoT and smart cities and the associated communication protocols the book provides an insight into its applications in several areas of smart cities Models architectures and algorithms are presented that provide additional solutions The main challenges discussed that are associated with IoT involved include security privacy authenticity etc The book is relevant to researchers academics professionals and students

Charge-Sharing SAR ADCs for Low-Voltage Low-Power Applications Taimur Rabuske, Jorge Fernandes, 2016-08-02 This book introduces readers to the potential of charge sharing CS successive approximation register SAR analog to digital converters ADCs while providing extensive analysis of the factors that limit the performance of the CS topology The authors present guidelines and useful techniques for mitigating the limitations of the architecture while focusing on the implementation under restricted power budgets and voltage supplies

Micro- and Nano-Systems in 21st-Century Vinayak Pachkawade, Koushik Guha, 2025-08-16 This book covers the principles operation and applications of the modern micro nano devices being developed to address global twenty first century challenges The subject of this book is Micro Nano Systems in the twenty first century The major areas of applications cover medical diagnostics 5G 6G communication inertial space

geography and resource exploration defense aviation etc This book provides the readers with a comprehensive outlook on the topics to help understand the physical scientific principles and techniques being applied to the design and development of devices sensors and actuators using Micro Nano System Technology MST The book addresses fabrication technologies such as CMOS MEMS Piezoelectric and other special MEMS processes where novel transducers are being designed and developed for ultrasound energy harvesting data storage computing inertial fluidics optomechanical etc The book serves as a tutorial guide to graduate students researchers engineers other large technical audiences and also the general public to understand these topics in a systematic and more thorough way by providing a range of illustrations comparative charts tables equations analysis and plots graphs In a nutshell the book is designed to provide a didactic approach to explaining scientific facts and figures in more lucid ways The students will get the engineering and scientific know how of modern micro and nano system technology a range of transduction principles and potential applied application areas Readers will understand through first hand equations principles of operations solved examples notes several illustrations and graphs how to design and develop a range of applications in microsystem technology

Index to Theses with Abstracts Accepted for Higher Degrees by the Universities of Great Britain and Ireland and the Council for National Academic Awards

,2008 **Powering Autonomous Sensors** María Teresa Penella-López, Manuel Gasulla-Forner, 2011-05-18 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

Analysis and

Optimal Design of Micro-energy Harvesting Systems for Wireless Sensor Nodes Xin Lu, 2012 Presently wireless sensor nodes are widely used and the lifetime of the system is becoming the biggest problem with using this technology As more and more low power products have been used in WSN energy harvesting technologies based on their own characteristics attract more and more attention in this area But in order to design high energy efficiency low cost and nearly perpetual lifetime micro energy harvesting system is still challenging This thesis proposes a new way by applying three factors of the system which are the energy generation the energy consumption and the power management strategy into a theoretical model to optimally design a highly efficient micro energy harvesting system in a real environment In order to achieve this goal three aspects of contributions which are theoretically analysis an energy harvesting system practically enhancing the system efficiency and real system implementation have been made For the theoretically analysis the generic architecture and the system design procedure have been proposed to guide system design Based on the proposed system architecture the theoretical analytical models of solar and thermal energy harvesting systems have been developed to evaluate the performance of the system before it being designed and implemented Based on the model s findings two approaches MPPT based power conversion circuit and the power management subsystem have been considered to practically increase the system efficiency As this research has been funded by the two public projects two energy harvesting systems solar and thermal powered wireless sensor nodes have been developed and implemented in the real environments based on the proposed work although other energy sources are given passing treatment The experimental results show that the two systems have been efficiently designed with the optimization of the system parameters by using the simulation model The further experimental results tested in the real environments show that both systems can have nearly perpetual lifetime with high energy efficiency

Energy Harvesting for Wireless Sensor Networks Olfa Kanoun, 2018-11-19 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

Energy Autonomous Micro and Nano Systems Marc Belleville, Cyril Condemine, 2012-12-17 Providing a detailed overview of the fundamentals and latest developments in the field of energy autonomous microsystems this book delivers an in depth study of the applications in the fields of health and usage monitoring in aeronautics medical implants and home automation drawing out the main specifications on such systems Introductory information on photovoltaic thermal and mechanical energy harvesting and conversion is given along with the latest results in these fields This book also provides a state of the art of ultra low power sensor interfaces digital signal processing and wireless communications In addition energy optimizations at the sensor node and sensors network levels are discussed thus completing this overview This book details the challenges and latest techniques available to readers who are interested in this field A major strength of this book is that the first three chapters are application orientated and thus by setting the landscape introduce the technical chapters There is also a good balance between the technical application covering all the system related aspects and within each chapter details on the physics materials and technologies associated with electronics

Self-Powered Internet of Things Muhammad Moid Sandhu, Sara Khalifa, Marius Portmann, Raja Jurdak, 2023-06-16 This book covers cutting edge advancements on self powered Internet of Things where sensing devices can be energy positive while capturing context from the physical world It provides new mechanisms for activity recognition without the need of conventional inertial sensors which demand significant energy during their operation and thus quickly deplete the batteries of internet of things IoT devices The book offers new solutions by employing energy harvesters as activity sensors as well as power sources to enable the autonomous and self powered operation of IoT devices without the need of human intervention It provides useful content for graduate students as well as researchers to understand the nascent technologies of human activity fitness and health monitoring using autonomous sensors In particular this book is very useful for people working on pervasive computing activity recognition wearable IoT fitness healthcare and autonomous systems This book covers a broad range of topics related to self powered activity recognition The main topics of this book include wearables IoT energy harvesting energy harvesters as sensors activity recognition and self powered operation of IoT devices This book starts with the introduction of wearable IoT devices and activity recognition and then highlights the conventional activity recognition mechanisms After that it describes the use of energy harvesters to power the IoT devices Later it

explores the use of various energy harvesters as activity sensors. It also proposes the use of energy harvesters as simultaneous source of energy and context information and defines the emerging concept of energy positive sensing compared to conventional energy negative sensing. Finally it explores sensor signal fusion to enhance the performance using multiple energy harvesters and charts a way forward for future research in this area. This book covers all important and emerging topics that have significance in the design and implementation of autonomous wearable IoT devices. We believe that this book will lay the foundation for designing self powered IoT devices which can ultimately replace the conventional wearable IoT devices which need regular recharging and replacement.

Design and Implementation of Energy Harvesting Powered Wireless Sensor Networks Dušan Vučković, 2014

Design of Vibrational and Solar Energy Harvesting Systems for Powering Wireless Sensor Networks in Bridge Structural Health Monitoring Applications Jacob Allan Adams, 2014

Structural health monitoring systems provide a promising route to real time data for analyzing the current state of large structures. In the wake of two high profile bridge collapses due to an aging highway infrastructure the interest in implementing such systems into fracture critical and structurally deficient bridges is greater now than at any point in history. Traditionally these technologies have not been cost effective as bridges lack existing wiring architecture and the addition of this is cost prohibitive. Modern wireless sensor networks WSN now present a viable alternative to traditional networking however these systems must incorporate localized power sources capable of decade long operation with minimal maintenance. To this end this thesis explores the development of two energy harvesting systems capable of long term bridge deployment with minimal maintenance. First an electromagnetic linear vibrational energy harvester is explored that utilizes the excitations from passing traffic to induce motion in a translating permanent magnet mass. This motion is then converted to electrical energy using Faraday's law of induction. This thesis presents a review of vibrational energy harvesting literature before detailing the process of designing, simulating, prototyping and testing a selected design. Included is an analysis of the effects of frequency, excitation amplitude, load and damping on the power production potential of the harvester. Second a solar energy harvester using photovoltaic PV panels is explored for powering the critical gateway component of the WSN responsible for data aggregation. As solar energy harvesting is a more mature technology this thesis focuses on the methodologies for properly sizing a solar harvesting system and experimentally validating the selected design. Fabrication of the prototype system was completed and field testing was performed in Austin TX. The results validate the selected system's ability to power the necessary 14 W DC load with a 0° panel azimuth angle facing direct south and 45° tilt.

Energy Harvesting for Self-powered Wireless Sensors Jason Wardlaw, 2012

A wireless sensor system is proposed for a targeted deployment in civil infrastructures namely bridges to help mitigate the growing problem of deterioration of civil infrastructures. The sensor nodes are self powered via a novel magnetic shape memory alloy (MSMA) energy harvesting material and a low frequency low power rectifier multiplier (RM). Experimental characterizations of the MSMA device and the RM are presented. A study on practical

implementation of a strain gauge sensor and its application in the proposed sensor system are undertaken and a low power successive approximation register analog to digital converter SAR ADC is presented The SAR ADC was fabricated and laboratory characterizations show the proposed low voltage topology is a viable candidate for deployment in the proposed sensor system Additionally a wireless transmitter is proposed to transmit the SAR ADC output using on off keying OOK modulation with an impulse radio ultra wideband IR UWB transmitter TX The RM and SAR ADC were fabricated in ON 0 5 micrometer CMOS process An alternative transmitter architecture is also presented for use in the 3 10GHz UWB band Unlike the IR UWB TX described for the proposed wireless sensor system the presented transmitter is designed to transfer large amounts of information with little concern for power consumption This second method of data transmission divides the 3 10GHz spectrum into 528MHz sub bands and hops between these sub bands during data transmission The data is sent over these multiple channels for short distances 3 10m at data rates over a few hundred million bits per second Mbps An UWB TX is presented for implementation in mode I 3 1 4 6GHz UWB which utilizes multi band orthogonal frequency division multiplexing MB OFDM to encode the information The TX was designed and fabricated using UMC 0 13 micrometer CMOS technology Measurement results and theoretical system level budgeting are presented for the proposed UWB TX

Autonomous Sensor Networks Daniel Filippini, 2012-11-27 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

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