Theme C: Modelling and Simulation

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Scientific contributions

Theme C has developed a novel simulation technique particularly suitable for modelling and optimisation of kinetic energy harvester systems where complex analogue and digital models are used in several technology domains: electrical, mechanical and magnetic. In addition, the components of an energy harvester operate in disparate time scales. This leads to prohibitive CPU times with the use of classical state-of-the-art techniques. The new technique takes advantage of the passivity of the analogue electronics in an energy harvester and accelerates CPU times by two orders of magnitude.

The fast linearised simulation technique was employed in the development of a design space explorer toolkit for a complete energy-harvester-powered sensor node. The design space explorer allows designers to investigate trade-offs between design parameters and their effect on the harvester's performance characteristics. The toolkit implements response-surface models of a number of performance characteristics and incorporates either real data or parametrized models of the vibration source, the energy harvester, tuning controller and wireless sensor node. Arbitrary test scenarios can be considered as the proposed approach permits the designer to adjust a wide range of system parameters and evaluate the effect almost instantly but still with high accuracy. In the developed toolkit, the estimated CPU time of one RSM estimation is in the microsecond range and the average performance estimation error is less than 16.5%.

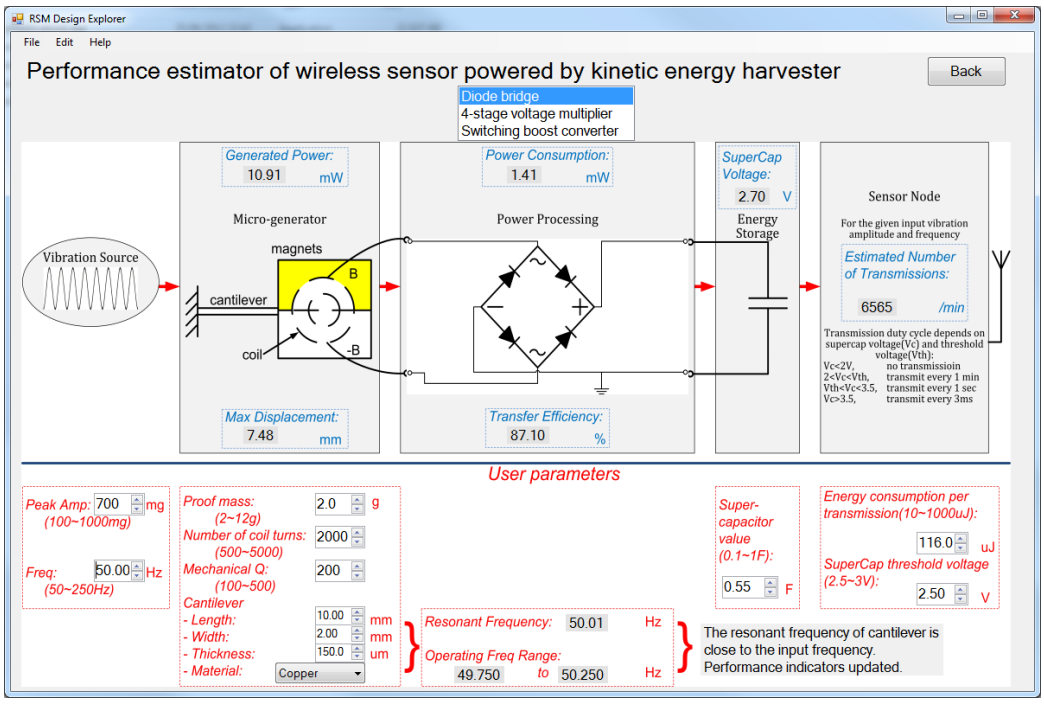


Fig. 1: Design explorer for a sensor node powered by a tunable energy harvester.

Publications

see http://www.holistic.ecs.soton.ac.uk/publications.php

T.J. Kazmierski, G.V. Merrett, L. Wang, B.M. Al-Hashimi, A.S. Weddell and I. Ayala Garcia, "Modeling of Wireless Sensor Nodes Powered by Tunable Energy Harvesters: HDL-Based Approach", IEEE Sensors Journal [in press]

T. Kazmierski, L. Wang, B. Al-Hashimi, and G. Merrett, "An explicit linearized state-space technique for accelerated simulation of electromagnetic vibration energy harvesters", IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems, Vol. 31, No. 4, pp. 522-531.

A. Weddell, G. Merrett, T. Kazmierski, and B. Al-Hashimi, "Accurate Supercapacitor Modeling for Energy-Harvesting Wireless Sensor Nodes", IEEE Transactions on Circuits and Systems II: Express Briefs, Vol. 58, No. 12, pp. 911-915.

A. Weddell, G. Merrett, and B. Al-Hashimi, "Photovoltaic Sample-and-Hold Circuit Enabling MPPT Indoors for Low-Power Systems". IEEE Transactions on Circuits and Systems I: Regular Papers, Vol. 59, No. 6, pp. 1196-1204.

L. Wang, T.J. Kazmierski, B.M. Al-Hashimi, M. Aloufi and J. Wenninger, "Response-surface-based design space exploration and optimisation of wireless sensor nodes with tunable energy harvesters". In Design, Automation and Test in Europe (DATE 2012), Dresden, Germany, 12 - 16 Mar 2012, pp. 733-738.

G. V. Merrett and A. S. Weddell, "Supercapacitor leakage in energy-harvesting sensor nodes: fact or fiction?", International Workshop Algorithms and Concepts for Networked Sensing Systems Powered by Energy Harvesters 2012 (EnHaNSS'12), Antwerp, Belgium, 11 June 2012. 5pp. [in press]

H. Huang, G. Merrett, and N. White, "Human-powered inertial energy harvesters: the effect of orientation, location and activity on obtainable power", Eurosensors XXV, 4-7 September 2011, Athens, Greece.

L. Wang, T. J. Kazmierski, B. M. Al-Hashimi, A. S. Weddell, G. V. Merrett, and I. N. Ayala Garcia, "Accelerated simulation of tunable vibration energy harvesting systems using a linearised state-space technique", Design, Automation and Test in Europe 2011 (DATE 2011), Grenoble, France, 14-18 March 2011, pp. 1267-1272 (Best Paper Candidate).

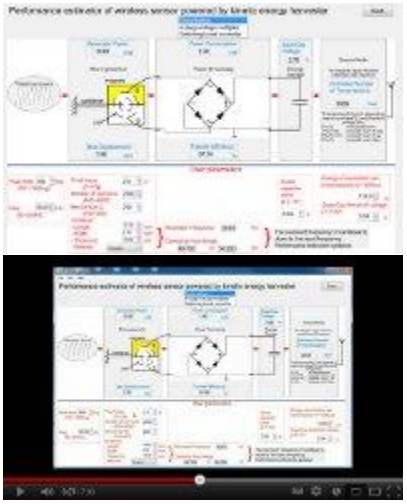
A. S. Weddell, G. V. Merrett, and B. M. Al-Hashimi, "Ultra Low-Power Photovoltaic MPPT Technique for Indoor and Outdoor Wireless Sensor Nodes", Design, Automation & Test in Europe 2011 (DATE 2011), Grenoble, France, 14-18 March 2011, pp. 905-908.

Other Resources, News and Events

see www.holistic.ecs.soton.ac.uk/resources.php)

Holistic Energy Harvesting Design Explorer and Simulation Toolkit

The Response Surface Model-based Design Explorer (Windows .exe), pictured right, is available for download. It allows you to adjust the design of the vibration energy harvesting system and see what effect it has on the number of transmissions a wireless sensor node can make. An Energy Harvesting Simulation Toolkit (.zip) package, which includes documentation, may also be downloaded.



Design Space Exploration and Optimisation of Energy Harvesting Systems

A video is available on the holistic website, where Dr Tom Kazmierski and Dr Leran Wang (Phil) discuss our design explorer, which is based on a "Response Surface Model" technique.

Our paper 'Modeling of Wireless Sensor Nodes Powered by Tunable Energy Harvesters: HDL-Based Approach' is one of the 25 most downloaded Sensors Journal papers in the month of June 2012. Included in this ranking are all Sensors Journal papers published since its foundation, about 1000 papers in total.

Our paper ‘Accelerated simulation of tunable vibration energy harvesting systems using a linearised state-space technique’ was a candidate for a best-paper award at the DATE 2011 conference.