holistic
energy harvesting

Theme C outputs

Holistic energy-harvesting project workshop and showcase
Imperial College, 11 Feb 2013

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Outline

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- Theme C objective
- Research Contributions
  - Accelerated simulation technique for energy harvesters based on linearised state-space equation formulation
  - Fast design explorer based on response surface modelling
  - Accurate supercapacitor modelling
- Software toolkit for fast design exploration
- Publications

Theme C objective

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- To develop an automated EH design flow that can
  - Specify micro generator type and find suitable/optimised dimensions
  - Identify suitable/optimised power processing configuration(s)
  - Based on the performance of a whole system and according to given excitation and application
- Component models – from Themes A and B
  - Micro-generator including different types of transduction (piezoelectric, electromagnetic and electrostatic) and mechanical structures (e.g. cantilevers, in-plane/out-of-plane gap closing)
  - Associated interface electronics, including storage elements (super-caps)
  - Computational logic loads (power profile)
- Design toolkit for modelling and performance optimisation

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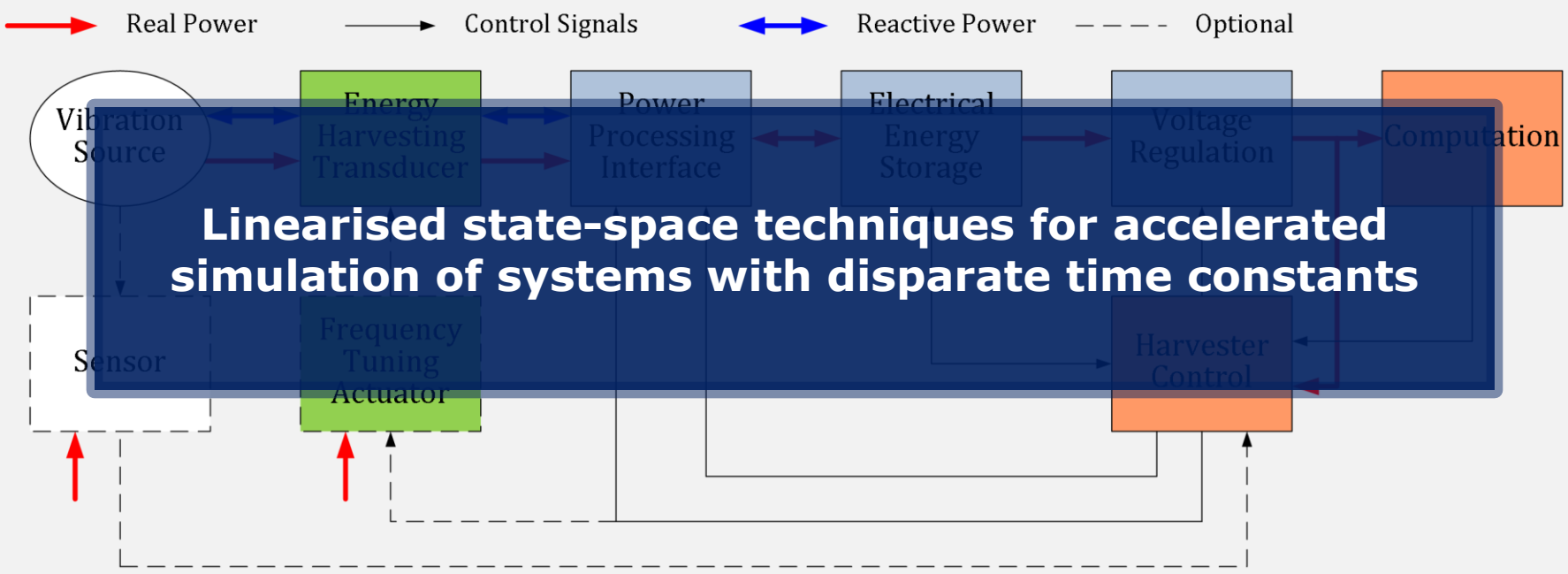
Theme C Scientific Contributions



A novel simulation technique particularly suitable for energy harvesting systems, which has demonstrated an increase in simulation speed of two orders of magnitude.

Output: 3 papers (DATE'11 - best paper candidate, IEEE Trans CAD 2012, IEEE Sensors J 2012), downloadable simulation toolkit
Institutions: Southampton (lead), Bristol, Imperial, Newcastle (collaborators)
Themes: Theme C, Theme A, Theme B

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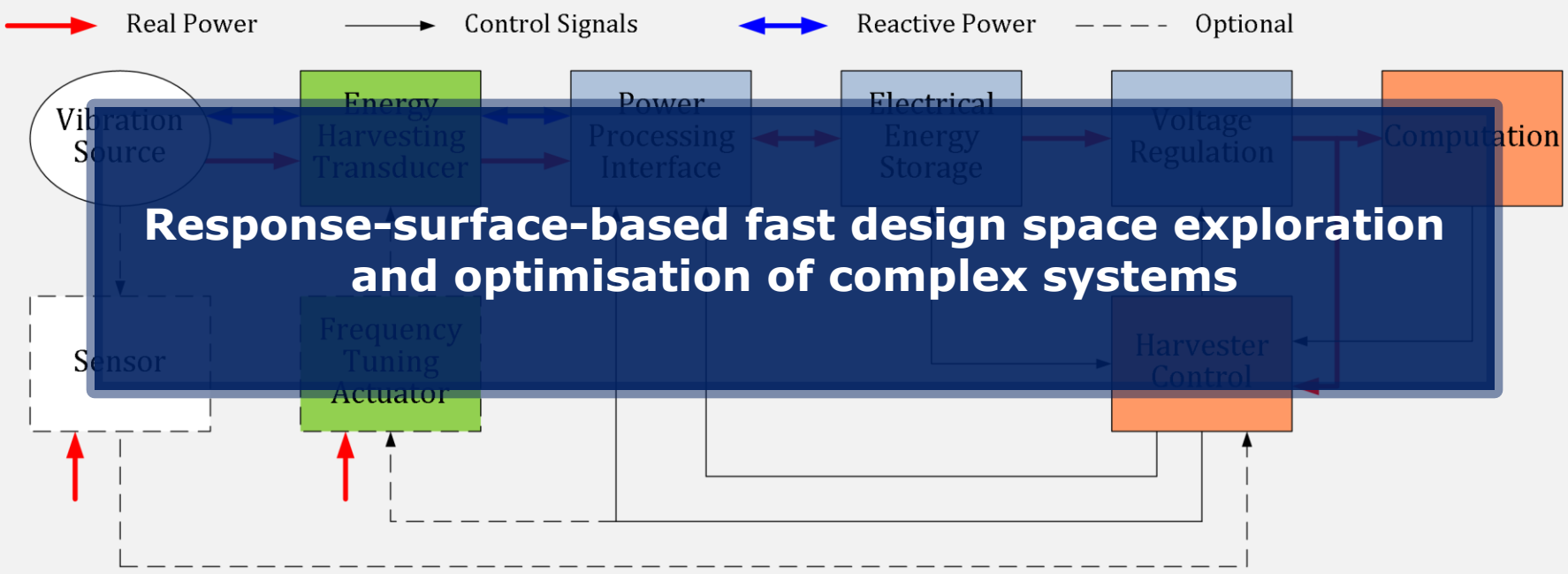
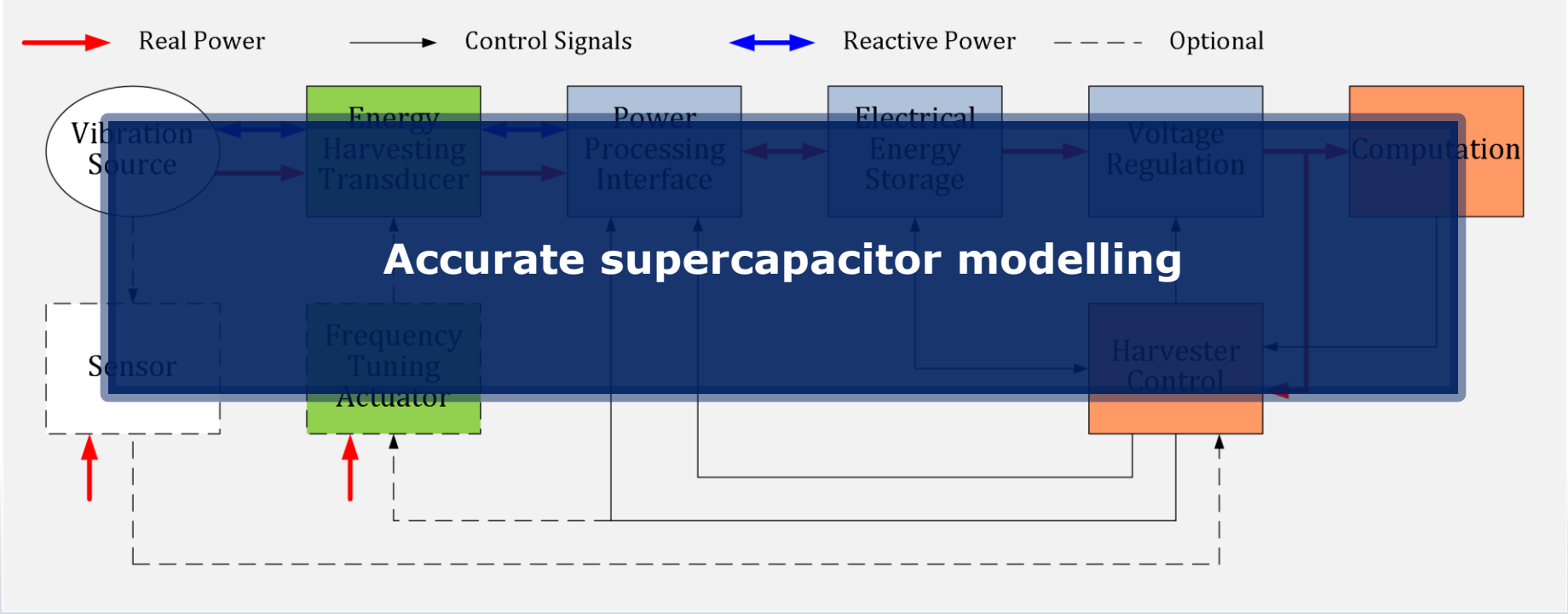
Theme C Scientific Contributions



A fast design space exploration and optimisation technique based on Response Surface Models, which has been demonstrated for wireless sensor nodes with energy harvesters.

Output: 1 paper (DATE'12), downloadable design space explorer
Institutions: Southampton (lead), Bristol, Imperial, Newcastle (collaborators)
Themes: Theme C, Theme A, Theme B

Theme C Scientific Contributions



Supercapacitor model with non-linear behaviour, multiple time constants and leakage.

Output: 2 papers (EnHaNSS'12, IEEE TCAS II, 2012)
Institutions: Southampton
Themes: Theme C,

Software Tool

- Holistic Energy Harvesting Design Explorer and Simulation Toolkit
  - Based on Response Surface Modelling Technique
  - It allows designers to adjust parameters of vibration energy harvesting system and instantly obtain desired performance trade-offs.
- Available for download from website
- Video is available on website, where Dr Tom Kazmierski and Dr Leran Wang (Phil) discuss the design explorer

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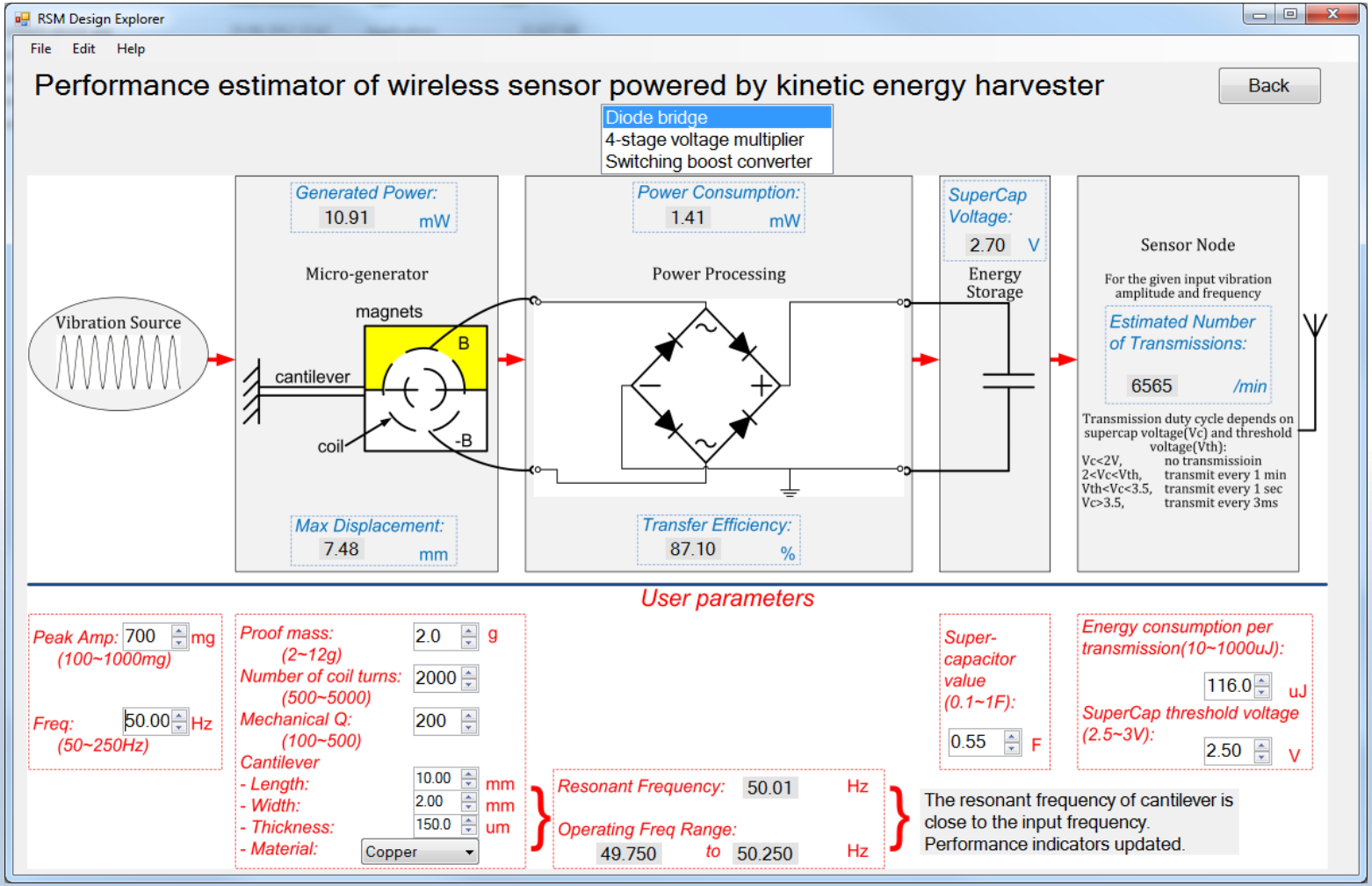
Energy Harvester Design Explorer



Publications

Accelerated simulation and fast design exploration

- 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, Aug 2012
- 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.
- 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).
- 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.

Publications

Supercapacitor modelling

- 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.
- 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.

Publications

Other related to Theme C

- 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.
- 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.
- 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