VIBRATIONAL AND THERMAL ENERGY HARVESTING USING SMART MATERIALS

A ONE-DAY SHORT COURSE
PRESENTED BY PROF D J INMAN
ON
29 OCTOBER 2007AT THE UNIVERSITY OF SWANSEA
AND AGAIN
1 NOVEMBER 2007 AT THE UNIVERSITY OF GLASGOW

A one-day short course is offered introducing the basic concepts of harvesting ambient vibrational and thermal energy using smart materials and structures for the purpose of running small electric devices. In the last four years there has been an explosion of both academic work and business products associated various forms of mechanical harvesting energy for powering small electronics. This course presents beginning level theories of energy harvesting from ambient vibration and ambient thermal gradients. Basic background in harvesting transducers, characterization of ambient energies, electric circuits, storage devices, duty cycles and applications will be presented. The course is a short version of the post graduate course taught at Virginia Tech.

COURSE SCHEDULE:

10:30 – 11:00 Registration, introductions, and coffee

11:00 – 12:00 Introduction to harvesting and overview
- motivation
- various methods
- sample systems

12:00 – 13:00 Simple models of smart materials for harvesting

1) piezoelectric materials (PZT)
- electromechanical coupling equations
- stack and bending modes
- deflection in voltage out
- electrical model

2) thermal electric materials (TEG)
- simple models
- temperature gradient
- sample systems

13:00 – 14:00 Lunch and informal questions and answers

14:00 – 15:00 Vibration basics for computing harvested energy
- Single Degree of Freedom model and base motion
- Coupling mechanism
- Harvesting circuits
- Optimal Energy harvesting
- Design rules

15:00 – 15:30 Electric circuit basics for harvesting and storage
- rectifying circuits
- storage circuits

- batteries versus capacitors
- duty cycles

15:30 – 16:00 Computing basics for harvested thermal energy
- Characterization of ambient thermal gradients for harvesting
- Design rules
- Storage for TEGs

16:00 – 16:30 Coffee and informal discussions

16:30 – 17:30 Comparison of PZT and TEG harvested energy to solar, etc.
- Power
- Voltage
- Current

17:30 – 18:00 Product review and examples
- A summary of available harvesting and storage products
- Where to go for more information

18:00 – 18:30 Questions, answers and the way forward

18:30 Adjournment to local pub for questions and incoherent answers

The fee is 50 GBP, which covers lunch and breaks. The course fees for students and academics is paid by a grant from EPSRC (travel not included).

FOR VENUE DETAILS IN SWANSEA CONTACT PROF ARTHUR LEES:

Professor Arthur W. Lees
School of Engineering
University of Wales Swansea
Singleton Park
Swansea SA2 8PP UK
Tel: 44 (0) 1792-295837
Fax: 44 (0) 1792-295676
A.W.Lees@swansea.ac.uk

FOR VENUE DETAILS IN GLASGOW CONTACT PROF MATTHEW CARTMELL:

M P Cartmell
James Watt Chair of Mechanical Engineering
University of Glasgow
Glasgow G12 8QQ, UK
m.cartmell@mech.gla.ac.uk

ABOUT THE INSTRUCTOR: **Daniel J. Inman** is the Director of the Center for Intelligent Material Systems and Structures and the G.R. Goodson Professor of Department of Mechanical Engineering at Virginia Tech in the US. Since 1980, he has published 7 books (on vibration, control, statics, and dynamics), eight software manuals, 20 book chapters, over 185 journal papers and 375 proceedings papers, given 34 keynote or plenary lectures, graduated 43 Ph.D. students and supervised more than 60 MS degrees. A number of these papers deal with energy harvesting including the first survey article on the topic. He is a Fellow of the American Academy of Mechanics (AAM), the American Society of Mechanical Engineers (ASME), the International Institute of Acoustics and Vibration (IIAV), and the American Institute of Aeronautics and

Astronautics (AIAA). He is currently Technical Editor of the *Journal of Intelligent Material Systems and Structures* (1999-), Technical Editor of the *Shock and Vibration Digest* (1998-), and Technical Editor of the journal *Shock and Vibration* (1999-). He has served as Technical Editor of *ASME Journal of Vibration and Acoustics* (1990-1999), and as Associate Editor of the following: *ASME Journal of Vibration and Acoustics* (1986-89), *ASME Journal of Applied Mechanics* (1988-94), *Mechanics of Machines and Structures* (1986-98), *International Journal of Analytical and Experimental Modal Analys*is (1986-1990) and *Journal of Intelligent Material Systems and Structures* (1992-1999) and *Smart Materials and Structures* (1991-2001). He is a founding member of the ASME Adaptive Structures and Material Systems Technical Committee and the AIAA Adaptive Structures Technical Committee. He won the ASME Adaptive Structures Award in April 2000, the ASME/AIAA SDM Best Paper Award in April 2001, the ASME Best Paper in Adaptive Structures in 2007 and the SPIE Smart Structures and Materials Life Time Achievement Award in March of 2003.