Tutorial Session

Title: Bond graphs and port-Hamiltonian formalisms for modelling and control of physical systems
Speaker: Alejandro Donaire, in collaboration with Sergio Junco and Tristan Perez

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Abstract:
This presentation focuses on bond graphs (BG) and port-Hamiltonian systems (PHS) as energy-based frameworks for both modelling of dynamical systems and control system design.
The bond graph methodology is a useful tool for (but not restricted to) modelling physical system. A BG model can be thought as graphical representation of the energy processing and transactions in a physical system and, simultaneously, of the mathematical relationships among the system variables. A characteristic of the bond graphs is that each BG component represents a physical phenomenon, and BG variables represent physical quantities. Bond graph models are built by interconnecting basic elements and/or more complex subsystems trough power ports in a modular procedure qualifying as an object-oriented modelling approach.
Port-Hamiltonian systems (PHS) have been presented in the control theory literature as a generalization of the classical Hamilton's equations of motion. The state space representation of PHS models has a special form that relates the functions and variables of the PHS model with the different energy phenomena present in the system (energy storage, dissipation, power conserving interconnection, environment-system energy exchange). Different control methods that exploit physical properties are available in the literature related to PHS, e.g. energy shaping, interconnection and damping assignment, integral action. These passivity-based techniques have been successfully applied to control system design in many engineering problems.
The first part of this talk is devoted to briefly introduce the BG and PHS models as well as the correspondence between their functions and variables. Second, control methods for port-Hamiltonian systems are discussed. These techniques are illustrated using the permanent magnet synchronous motor.

Short profile:

Alejandro Donaire was born in Rosario, Argentina. He received the undergraduate degree and PhD in Electronic Engineering from the Faculty of Engineering (FCEIA) of Universidad Nacional de Rosario (UNR), Argentina, in 2003 and 2009, respectively. His work was supported by The Argentine National Council of Scientific and Technical Research (CONICET). He had two short research stages at LAGIS, Ecole Centrale de Lille, France, in 2003 and 2004. He was a teaching assistant in two undergraduate courses, one on System Dynamics and Control and the other on Control of Electrical Drives, both at FCEIA-UNR. In August 2009, he took a full-time research academic position at the Centre for Complex Dynamic Systems and Control. His research focuses on Port-Hamiltonian System, Nonlinear Energy-Base Control, Motion Control Systems, and Marine and Aerospace Control Applications. Within this job, he collaborates in two industry projects. One project is with Boeing Research and Technology Australia and the other with CFW Hamilton Jet (New Zealand) on the topic of motion control of marine vessels with water jets.