2SC5691 – Regulation and control of energy production and conversion systems

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Department: DOMINANTE - ENERGIE
Language of instruction: FRANCAIS
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 40
On-site hours (HPE): 27,00

Description
This "Challenging Week" entitled "Energy production and conversion" aims to tackle the regulation issues of several electrical energy production units, linked to the transport or distribution network. The considered systems to be studied will be for instance (list to be confirmed when the project subjects will be available) an hydroelectric production unit, a wind farm, a cogeneration or a photovolatic production unit.
The work to be done will be divided into few main steps:
- development of a model of the energy production unit based on given documents and data
- design of a control law for the production unit in face with specifications well suited to the considered problem
- Validation based on simulations of the regulation law.
These studied will be partly carried out in collaboration with EDF and in particular with the "Centre d'Ingénierie Hydraulique" located in Bourget-du-Lac.
Depending on the considered case, the work will consist in reproducing the observed behaviour of the controlled production unit, enhancing the performance of the regulation, or investigating an innovative operating mode for the production unit.

Quarter number
ST5

Prerequisites (in terms of CS courses)
- Control Theory (Second year core module, ST5)
- Introduction to energy production (module in the Engineering Challenge Term ST5 "Multi-energy systems")

Syllabus
Outline of the Challenging Week :

- First half-day: presentation and choice of the projects
- Half-days 2 to 8 : project completion
    - Handling of the proposed issue and corresponding available documents and data
    - Design of a nonlinear simulator for the open-loop production unit
    - Determination of a model well suited to control purposes
    - Computation of the control law in face with dedicated specifications for the considered unit
    - Definition, if possible, of an innovative control law strategy
    - Validation based one the nonlinear simulator
- Last half-day: oral presentation of the results

Class components (lecture, labs, etc.)

Project, made by groups of 4 or 5 students.
Supervision by teachers from CentraleSupélec.

Grading

Each group of 4 or 5 students should provide:
- a full simulator of the work done, including a non linear simulator of the system, control law and validation files;
- a report explaining the proposed approach and in particular the way to use the simulator and the codes;
- an oral presentation of the work

Skills C1, C2 and C6 will be specifically assessed
"C1 Analyze, design and build complex systems with scientific, technological, human and economic components", in particular by justifying the approach adopted
"C2 Develop in-depth skills in an engineering field and in a family of professions", in particular by analyzing the results obtained with regard to the application in question
"C6 Being operational, responsible and innovative in the digital world", in particular through the deliverables (simulators)

Course support, bibliography

N. Gionfra, H. Siguerdidjane, G. Sandou, D. Faille, and P. Loevenbruck. Combined Feedback Linearization and MPC for Wind Turbine Power Tracking. 2016 IEEE Multi-Conference on Systems and Control, International Conference on Control Applications, Buenos Aires, Argentina, September 19th-22nd, 2016.

Boubekeur Boukhezzar and Houria Siguerdidjane. Nonlinear Control of a Variable-Speed Wind Turbine Using a Two-Mass Model. IEEE Transactions on Energy Conversion, vol. 26, no. 1, Mars 2011.
Morten Hartvig Hansen and Lars Christian Henriksen. Basic DTU Wind Energy controller. DTU Wind Energy E-0018. January 2013.
Gérard Robert, Frédéric Michaud. Reduced Models for Grid Connected Hydro Power Plant Application to Generation Control. International Conference on Communications, Computing and Control Applications. 3-5 March 2011. Hammamet, Tunisia
Nicola Femia, Giovanni Petrone, Giovanni Spagnuolo, and Massimo Vitelli. Optimization of Perturb and Observe Maximum Power Point Tracking Method. IEEE Transaction on Power Electronics, Vol. 20, No. 4, July 2005
Rae-Young Kim, and Jih-Sheng Lai. Seamless Mode Transfer Maximum Power Point Tracking Controller For Thermoelectric Generator Applications. IEEE Transaction on Power Electronics, vol. 23, no. 5, September 2008

Resources
- Teachers from the Control Department and Energy Department;
- Contacts and meetings with research engineers from EDF;
- Documents and data about electricity production units;
- Use of students' laptops

Learning outcomes covered on the course
At the end of this module, students will be able to
- Model a physical and industrial system for control purposes;
- Capture the impact of a production unit regulation ob the global operation of the electrical system;
- Model a system, from a functional point of view , so as to determine the control strategy;
- Develop a control law in face with some specifications;
- Take into account the specificities of some energy production units;
- Validate the behaviour of a controlled electricity production unit.

Description of the skills acquired at the end of the course
C1.1 Examine problems in their entirety and beyond their immediate parameters. Identify, formulate and analyse the scientific, economic and human dimensions of a problem
C1.2 Develop and use appropriate models, choosing the correct modelling scale and simplifying assumptions when addressing a problem
C1.3 Apply problem-solving through approximation, simulation and experimentation. / Solve problems using approximation, simulation and experimentation
C1.4 Design, detail and corroborate a whole or part of a complex system
C2.1 Thoroughly master a domain or discipline based on the fundamental

sciences or the engineering sciences.
C3.6 Evaluate the efficiency, feasibility and strength of the solutions offered. / proposed solutions
C3.7 Make pragmatic and informed choices with the aim of producing tangible results.
C7.1 Persuade at core value level; to be clear about objectives and expected results. To apply rigour when it comes to assumptions and structured undertakings, and in doing so structure and problematise the ideas themselves. Highlight the added value
C8.1 Work collaboratively in a team