Advanced FPGA-based Controllers for

Power Electronic and Drive Applications

Organizer: Associate Professor, Juan C. Vasquez, Professor Josep M. Guerrero

Lecturers: Professor Eric Monmasson, University of Cergy-Pontoise, Assistant Professor Mattia Ricco (AAU).

ECTS: 3

Date/Time: April 10th - April 12th, 2019

Max no. of participants: 20

Description: Digital controllers are now extremely powerful. With the current Field Programmable Gate Array (FPGA), designing a controller is no longer limited to the programming of a microprocessor but includes also the programming of the architecture of the processor itself along with its peripherals and its computing accelerators. As a consequence, the control designer should be now a system architect who also needs a deep understanding of the final system to be controlled. Along this line, this course aims to propose a rational use of current FPGA-based reconfigurable platforms for controlling power electronic and drive applications.

The following topics are covered in the course:

1st day (optional for students who have already worked with FPGAs): - Introduction, presentation of the current trends in terms of digital control implementation for electrical systems.

- Description of FPGA components (Internal architecture of FPGAs, recent System-on-Chip extension, presentation of the corresponding development tools), VHDL reminders.

- Hands-on basic examples, tutorial on a current FPGA development tool chain.

2nd & 3rd days: - Main design rules of an FPGA-based controller: Control algorithm refinement (design of a time continuous controller, internal delay issues, digital re-design, sampling issues, quantization issues). Architecture refinement (algorithm / architecture matching, IP-modules reusability, Hardware-In-the-Loop (HIL) validation, system-on-chip extension, High Level Synthesis (HLS) design approach).

- Presentation of practical cases: Current control of a synchronous motor drive, sensorless control techniques (Kalman filtering, high frequency injection), Adaptive MPPT for PV applications, Fault tolerant control of Voltage Source Rectifier.

- Hands-on the FPGA-based control of a power converter connected to the grid. Design of different types of regulators (PI current controller, PR current controller, sliding mode current controller, predictive current controller) and their corresponding Simulink-based and HLS-based IP modules. HiL validation.

Form of evaluation: The participants will be grouped and asked to team work on several case study scenarios and tasks proposed along the course. The assessment in this course will be done through a final multi-choice test in combination with delivery of exercises reports

Prerequisites: Matlab/Simulink knowledge and C/C++basic knowledge is recommended for the exercises.

Link: http://www.et.aau.dk/phd/phd-courses/