Master thesis subjects + Internships, proposals for 2022-2023

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A longer and updated list will be available by the end of May.

Suggestions are also welcome. Relevant domains: electrical machines (modelling, control, design, experimental work), wind turbines (generators and power converters), etc.

Test bench design and implementation for a FPGA-controlled PMSM

Contact person: Geoffrey Postal (geoffrey.postal@ulb.be)

In our lab, most of the electrical machines used for research are controlled via rapid prototyping modules from dSPACE. This allows to have an easy and user-friendly implementation of the controller using Simulink without having to care too much about hardware considerations. The purpose of this master thesis is to design and implement a machine test-bench using an FPGA from Xilinx. Thus, the job at hand will be mostly experimental with a large part of FPGA coding along with hardware considerations.

dSPACE : https://www.dspace.com/fr/fra/home/products/sw/experimentandvisualization/controldesk.cfm

Xilinx : https://www.xilinx.com/products/boards-and-kits/ek-z7-zc702-g.html

Model-based torque ripple reduction of a PMSM

Contact person: Geoffrey Postal (geoffrey.postal@ulb.be)

Electrical machines are prone to different nonidealities. Among others, slotting effects cause ripples in the currents and torques. For some application, e.g. power steering, this torque ripple should be as low as possible. The purpose of this master thesis is to use high-fidelity model of an electrical machine in the control to reduce the torque ripple. FE models can be very accurate; however, the computation cost is prohibitive for this kind of application. Thus, reduced order model will have to be developed using look-up tables or artificial neural network. In this master thesis, several simulations in Simulink will have to be implemented (machine model, improved controller testing…). Additionally, if desired some experimental work could be added for testing the improved controller previously designed on an experimental test bench.

Reference: Veeser, Felix, Tristan Braun, Lothar Kiltz, and Johannes Reuter. "Nonlinear Modelling, Flatness-Based Current Control, and Torque Ripple Compensation for Interior Permanent Magnet Synchronous Machines." *Energies* 14, no. 6 (2021): 1590.

Interturn short-circuit modelling of electrical machines

Contact person: Geoffrey Postal (geoffrey.postal@ulb.be)

Electrical machines are prone to interturn short-circuit fault. The accurate modelling of this kind of fault is of major importance due to the high currents induced during the fault which makes difficult to build experimental setup that emulates the fault without destructing the machine. The purpose of this master thesis will be to develop several machine models with an inter-turn short circuit fault. These models will then be used to test some fault detection algorithms. The job at hand will mostly be simulation work: FE modelling (in Gmsh/GetDP) and model development in Matlab/Simulink.

Reference: Alvarez-Gonzalez, Fernando, Antonio Griffo, Bhaskar Sen, and Jiabin Wang. "Real-time hardware-in-the-loop simulation of permanent-magnet synchronous motor drives under stator faults." *IEEE Transactions on Industrial Electronics* 64, no. 9 (2017): 6960-6969.

Real-time FPGA-based modelling of 6-phase PMSM

Contact person: Geoffrey Postal (geoffrey.postal@ulb.be)

With real-time machine models, information about the machine state not available with measurements (flux-linkages, torque) can be used in the controller. For real-time simulation, FPGA is very interesting because of its parallel computation capabilities. However, high-fidelity modelling of multi-phase machines is difficult due to the high number of degrees of freedom. The purpose of this master thesis will be to develop several FPGA-friendly models for a 6-phase PMSM. The job at hand will cover simulation job in Simulink and FPGA coding.

Reference:

- Bai, Hao, Chen Liu, Elena Breaz, and Fei Gao. "Artificial neural network aided real-time simulation of electric traction system." *Energy and AI* 1 (2020): 100010.
- Mohammadi, Abdolmajid Abedini, Johan Gyselinck, and Adrian-Cornel Pop. "Dynamic modeling of dual-star permanent-magnet synchronous machines using look-up tables." In *2019 Electric Vehicles International Conference (EV)*, pp. 1-6. IEEE, 2019.

Detection of switch faults in 3-phase grid-connected inverters

Contact person: Mohamed-Amine Yahiaoui (mohamed-amine.yahiaoui@ulb.be)

Grid-connected inverters are indispensable components in many renewable energy systems, e.g. PV systems and wind turbines. For the latter application in particular, maintenance costs and downtime losses can be reduced by fault detection and fault tolerance. The most common faults that affect inverters are open-circuited and short-circuited switches (IGBTs, MOSFETs...). The fault detection and isolation can be based on the analysis of the current waveforms, among other approaches; isolation in this context means determining the type and location of the fault. The student(s) will study this in simulation (Simulink) and next experimentally, starting from a healthy inverter. Basic knowledge of power electronics is required (or can be acquired on the fly).

Internships at and MSc theses in collaboration with Siemens Leuven

Contact person: Fabien Chauvicourt (fabien.chauvicourt@siemens.com)

1. E-machine vibration prediction tools – speed and processing improvements

   The objective is to enhance the computing capabilities of the internal e-NVH prediction tools (NoiseApp and Vibro-acoustic synthesis). The student will investigate techniques to reduce memory intensive processes in the code, implement advanced post-processing algorithms and aim at demonstrating the results within an already structured software app. A solid knowledge in electric machine working principles, modelling techniques, mechanical engineering, signal processing and coding is strongly valuable.

2. Development of a small electric test bench (power steering application)

   The objective is to develop and initiate the creation and building of a small test bench including two electric machines, a coupling, inverters and a control unit. The student will be given the components of a test bench and will have to ensure the safe operation of the bench together with ensuring that one can control the bench in various operating conditions. A solid knowledge in electric machine/powertrain working principles and practical understanding is highly appreciated.

Internships at and MSc theses in collaboration with Brose, Wurzburg, Germany

Contact person: Johan Gyselinck

1. Modelling the impact of magnet and its mounting process quality on the cogging toque and performance for an SPM Motor.
2. Magnetization process of a magnet in the magnetization yoke

Internships at and MSc theses in collaboration with Hitachi Energy (formerly ABB), Jumet, Charleroi

Contact person: Johan Gyselinck

1. Harmonics filtering control
2. New grid sensing solutions for Battery Storage Systems
3. Plug & Play active Filter