UCLouvain

lelme2313

2023

Dynamic modelling and control of electromechanical converters

5.00 credits	30.0 h + 30.0 h	Q1

Teacher(s)	De Jaeger Emmanuel ;Dehez Bruno ;
Language :	English > French-friendly
Place of the course	Louvain-la-Neuve
Main themes	- Dynamic models of DC machines - Dynamic models of synchronous machines - Dynamic models of asynchronous machines - Space phasors and variable transformations (Concordia, Park and Clarke) - Control of DC and BLDC machines - Vector and scalar control of asynchronous machines - Vector control of synchronous machines
Learning outcomes	**At the end of this learning unit, the student is able to :** 1 **Contribution of the course to the program objectives (N°)** Axis 1 (1.1, 1.2, 1.3), Axis 3 (3.3), Axis 5 (5.6) **Specific learning outcomes of the course** At the end of the course, the student will be able to : - Derive the dynamic model of electromechanical converters (DC and brushless DC machines, synchronous and asynchronous machines) in order to control them, in particular by exploiting the variable transformations (Concordia, Park and Clarke). - Describe the main control strategies of these converters (scalar V/f control of asynchronous machines, vector and direct torque control for asynchronous and synchronous machines) and choose them according to the application. - Use the adapted dynamic models in order to simulate the dynamic behaviour of these converters - Use the adapted dynamic models in order to synthesize type P, PI or PID controllers. - Use the adapted dynamic models in order to check the robustness and performance of a controller regarding modelling simplifications, external disturbances, changes in the machine parameters, ...
Evaluation methods	Students will be graded : • Collectively on the basis of the reports of the assignments carried out during the semester; • Individually on the basis of an oral exam on the content of the lectures and assignments. The weighting given to the grading of the homework will be • 40% if the grade of the oral exam is higher than 10/20; • 0% if the grade of the oral exam is lower than 5/20; • linearly progressive between 0%, if the grade of the oral exam is 5/20, and 40%, if the grade of the oral exam is 10/20. The grade for homework may be individualised according to the student's involvement in the group during the semester (e.g. active participation in consultancy sessions and report writing). The use of generative AI software such as chatGPT is permitted only for assistance in writing of the reports requested in this course. In this instance, however, an appendix will be required detailing, for each of the sections concerned, how the AI was used (information search, drafting and/or correction of the text, ...). Furthermore, external sources of information must be systematically cited in compliance with bibliographic referencing standards.
Teaching methods	Teaching is organized in the form of: • Lectures; • Homework on modelling and control of the various electromechanical converters seen during the lectures. The homework are performed in groups of 2 or 3 students and lead to a synthesis report, which is evaluated and is involved in the final evaluation of the course.

Content	Electromechanical converters transform electrical energy into mechanical energy, and vice versa. They play a crucial role in many areas, such as energy production, the rational use of electrical energy, and electric mobility, and therefore constitute an essential link in the energy transition. In this context, understanding the dynamic operation and the control methodologies of these converters form the general objectives of this course. More specifically, it covers the following content: • Introduction (1 hour): motivations, types of models, general structure of an electrical drive system, factors of development of electrical drive systems • DC machine model (2h): structure of the machine; excitation mode, dynamic equations in the time domain and in the Laplace domain; model simplifications (mechanical, electrical and electromechanical time constants); model improvements (armature resistance, saturation) • Space phasors and variable transformations (2 hour): Concordia Clarke and Park transformations • Synchronous machine model (4h): equations of the machine in 'abc', 'ab' and 'dq' coordinate systems; round rotor and salient pole machines; particularization to permanent magnet machines • Asynchronous machine model (4h): equations of the machine in 'abc', 'ab' and 'dq' coordinate systems • DC machine control (2h): general principle, main types of power supply, control with emf compensation, control with and without current measurement for low power machines • Synchronous machine control (4h): general principle of vector control in the 'dq' coordinate system; control with emf compensation, taking into account the inverter and the digital controller; flux weakening; particularization to surface mounted and interior permanent magnet machines, salient pole and wound inductor machines; brushless DC machines • Asynchronous machine control (4h): equations in the rotor flux coordinate system; general principle of vector control in this coordinate system; vector control with emf compensation; scalar V/f control • Electromechanical converters control concepts applied to electricity generation, with special emphasis on wind conversion (2h)
Inline resources	https://moodle.uclouvain.be/course/view.php?id=1272
Bibliography	- Slides - Books (available online via the intranet UCL): • Wach, P., Dynamics and control of electrical drives, Springer, 2011, 456 p. • Veltman, A., Pulle, D. W., De Doncker, R. W., Fundamentals of electrical drives, Springer, 2007, 346 p. • De Doncker, R. W., Pulle, D. W., Veltman, A., Advanced electrical drives: Analysis, Modeling, Control, Springer, 2011, 462 p.
Other infos	Concerning the homework: • Supervised sessions are organized weekly in a computer classroom • The software used is Matlab/Simulink
Faculty or entity in charge	ELME

Programmes containing this learning unit (UE)

Program title	Acronym	Credits	Prerequisite	Learning outcomes
Master [120] in Electrical Engineering	ELEC2M	5		
Master [120] in Electro-mechanical Engineering	ELME2M	5		
Master [120] in Energy Engineering	NRGY2M	5		