Course guide
340601 - MCME-R1O09 - Modelling and Control of Electrical Machines

Last modified: 17/05/2023

Unit in charge: Vilanova i la Geltrú School of Engineering
Teaching unit: 709 - DEE - Department of Electrical Engineering.

Degree: MASTER'S DEGREE IN AUTOMATIC SYSTEMS AND INDUSTRIAL ELECTRONICS (Syllabus 2012). (Compulsory subject).

Academic year: 2023 **ECTS Credits:** 5.0 **Languages:** Catalan, Spanish

LECTURER

Coordinating lecturer: Balduí Blanqué Molina

Others: Balduí Blanqué Molina

PRIOR SKILLS

Knowledge of electrical machines and their operating principle and fundamental equations.
Knowledge of power electronics basic level of solid state converters commonly used in engines.
Converters applied to semiconductor devices and circuits associated with the preparation of the measure, signal and protection.
Systems theory, block diagrams, systems analysis and design of controllers and drivers.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. CC03 -Ability to model any type of electrical machine and simulate its electromechanical behavior
2. CC04 - Ability to determine and design the most efficient electric drive for different control applications
movement
4. CG02 - Ability to apply the techniques of control and regulation of electric machines for motion control.
5. CG03 - Ability to combine various electronic functional blocks for a complex system.
6. (ENG) CG01 - Ability to research, design, develop and characterize the dynamics of complex systems that must be controlled to meet certain demanding operational performance at the operational level and security level, noticing some restrictions components and the possibility of failures in the control system

7. CC01 - Ability to research, design, develop and characterize advanced control systems that enable the dynamic system behave according to the operational performance requirements.
8. CG04- Ability to research, design, develop and implement simulation methods for the control of electronic systems, automatic and robotic

Transversal:
3. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.

TEACHING METHODOLOGY

LEARNING OBJECTIVES OF THE SUBJECT

1. Modeling and control of electric drives.
2. Special attention to the modeling of all stages that constitute a drive and simulation using PSpice and commercial software Matlab / Simulink will be given.
3. In the labs students will be introduced into the specifics of control currently used in the drive industry, introducing rapid prototyping techniques (DSpace) for the actual implementation using DSP's.
IN GENERAL:
Applications using electric drives require controls position, speed and torque. Today the applications in automated industrial processes and transport vehicles and trains use as precise and efficient motion control. Proper design of the whole minimizes energy consumption and the size and weight of the machines that move. On this subject the various systems used in the movement of drives (motors, sensors, converters, protocols, standards and control methods) for a wide variety of industrial sectors are covered.
The course aims to provide a broad view of the whole applied to real industrial processes.

STUDY LOAD

Type	Hours	Percentage
Hours large group	22,5	18.00
Hours small group	22,5	18.00
Self study	80,0	64.00

Total learning time: 125 h

CONTENTS

1. Introduction to electric drives applied to speed, position and torque control.

Description:
Introducció als tipus d'accionaments, sistemes elèctrics i mecànics.

Related competencies :
CC04. CC04 - Ability to determine and design the most efficient electric drive for different control applications movement

Full-or-part-time: 6h
Theory classes: 2h
Laboratory classes: 2h
Guided activities: 1h
Self study : 1h

2. Modelat dinàmic, Simulació i Control de les màquines elèctriques bàsiques (Continua i Inducció).

Description:
El modelado y la simulación de los accionamientos eléctricos nos permiten comprobar el funcionamiento de estos sin la necesidad de disponer de ellos físicamente, aunque los resultados son aproximados en función de la precisión del modelo. En este punto se mostrarán los diferentes sistemas de modelar que existen para accionamiento eléctricos y se presentarán los primeros modelos de máquina de continua y motor de inducción, realizando la simulación de estos de forma análoga a lo que se experimentará en el laboratorio.

Specific objectives:
1. Distinguir los diferentes tipos de modelado, relacionados con los parámetros que se desean analizar u observar en la simulación.
2. Saber configurar un accionamiento básico completo (Convertidor, drivers, sensores, motor, carga, etc) tanto en la simulación como en el laboratorio emulando o usando una aplicación real.
3. Comparar los resultados obtenidos y mejorarlos para una aplicación concreta.
4. Comprender como interactuan entre si las diferentes variables eléctricas y mecánicas, para saber como controlarlas.
5. Ajustar los diferentes bloques que intervienen en el funcionamiento del accionamiento.
6. Proponer y comprobar diferentes soluciones para un modelado orientado a resultados (En función de que se quiere observar; velocidad, rendimiento, corriente de bus, rizado de par, etc) evaluando el coste que esto tiene y los recursos necesarios para ello.

Related activities:
Ejercicios de conceptos básicos : Se realizan aplicando la simulación para dar apoyo experimental a los conceptos teóricos explicados en la clase de teoria. Alguno de estos ejercicios serán del tipo E1 evaluable y otros del mismo tipo, pero no evaluables.
Prácticas de laboratorio: Donde se obtienen los parámetros de los motores que se va a modelar y luego simular. Además también se contrastan los resultados dinámicos obtenidos en la simulación con los obtenidos en el laboratorio. Pudiendose observar a que se deben las similitudes y las diferencias. Práctica 1-2-3

Related competencies :
CG03. CG03 - Ability to combine various electronic functional blocks for a complex system.
CC04. CC04 - Ability to determine and design the most efficient electric drive for different control applications movement
CC03. CC03 -Ability to model any type of electrical machine and simulate its electromechanical behavior
CG04. CG04- Ability to research, design, develop and implement simulation methods for the control of electronic systems, automatic and robotic

Full-or-part-time: 16h
Theory classes: 6h
Laboratory classes: 6h
Guided activities: 2h
Self study : 2h

(ENG) Control escalar y vectorial de las màquines elèctriques.

Description:
Control escalar y vectorial de las màquines elèctriques.

Full-or-part-time: 11h 40m
Theory classes: 5h
Laboratory classes: 3h 20m
Guided activities: 1h 40m
Self study : 1h 40m

4. Modelat i control d'accionaments no convencionals.

Description:
Modelat i control d'accionaments de Reluctància Autoconmutats.
Modelat i control d'accionaments lineals.

Related competencies :
CG01. (ENG) CG01 - Ability to research, design, develop and characterize the dynamics of complex systems that must be controlled to meet certain demanding operational performance at the operational level and security level, noticing some restrictions components and the possibility of failures in the control system

CG03. CG03 - Ability to combine various electronic functional blocks for a complex system.
CG02. CG02 - Ability to apply the techniques of control and regulation of electric machines for motion control.
CC04. CC04 - Ability to determine and design the most efficient electric drive for different control applications movement
CC03. CC03 -Ability to model any type of electrical machine and simulate its electromechanical behavior
CC01. CC01 - Ability to research, design, develop and characterize advanced control systems that enable the dynamic system behave according to the operational performance requirements.
CG04. CG04- Ability to research, design, develop and implement simulation methods for the control of electronic systems, automatic and robotic
05 TEQ. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.

Full-or-part-time: 6h
Theory classes: 1h
Laboratory classes: 1h
Guided activities: 2h
Self study : 2h

ACTIVITIES

E1. Concept exercises (20%)

Related competencies :
CC01. CC01 - Ability to research, design, develop and characterize advanced control systems that enable the dynamic system behave according to the operational performance requirements.
CG02. CG02 - Ability to apply the techniques of control and regulation of electric machines for motion control.
CG03. CG03 - Ability to combine various electronic functional blocks for a complex system.
CG04. CG04- Ability to research, design, develop and implement simulation methods for the control of electronic systems, automatic and robotic
CG01. (ENG) CG01 - Ability to research, design, develop and characterize the dynamics of complex systems that must be controlled to meet certain demanding operational performance at the operational level and security level, noticing some restrictions components and the possibility of failures in the control system

CC04. CC04 - Ability to determine and design the most efficient electric drive for different control applications movement
05 TEQ. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.

Full-or-part-time: 5h
Theory classes: 1h
Guided activities: 2h
Self study: 2h

Ep. Exàmen parcial (20%)

Related competencies :
CG04. CG04- Ability to research, design, develop and implement simulation methods for the control of electronic systems, automatic and robotic
CG03. CG03 - Ability to combine various electronic functional blocks for a complex system.
CG02. CG02 - Ability to apply the techniques of control and regulation of electric machines for motion control.
CC03. CC03 -Ability to model any type of electrical machine and simulate its electromechanical behavior
CG01. (ENG) CG01 - Ability to research, design, develop and characterize the dynamics of complex systems that must be controlled to meet certain demanding operational performance at the operational level and security level, noticing some restrictions components and the possibility of failures in the control system

Full-or-part-time: 2h
Theory classes: 2h

E_lab. Evaluació de pràctiques (20%)

Related competencies :
CG03. CG03 - Ability to combine various electronic functional blocks for a complex system.

Full-or-part-time: 1h
Theory classes: 1h

Ef. Exàmen final (20%)

Full-or-part-time: 2h
Theory classes: 2h

ET. Practical work (20%)

Description:
Teamwork to start up an applied drive.

Related competencies :
CC03. CC03 -Ability to model any type of electrical machine and simulate its electromechanical behavior
CC01. CC01 - Ability to research, design, develop and characterize advanced control systems that enable the dynamic system behave according to the operational performance requirements.
CG03. CG03 - Ability to combine various electronic functional blocks for a complex system.
CG01. (ENG) CG01 - Ability to research, design, develop and characterize the dynamics of complex systems that must be controlled to meet certain demanding operational performance at the operational level and security level, noticing some restrictions components and the possibility of failures in the control system

CC04. CC04 - Ability to determine and design the most efficient electric drive for different control applications movement
CG04. CG04- Ability to research, design, develop and implement simulation methods for the control of electronic systems, automatic and robotic
CG02. CG02 - Ability to apply the techniques of control and regulation of electric machines for motion control.
05 TEQ. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.

Full-or-part-time: 7h
Practical classes: 5h
Laboratory classes: 2h

GRADING SYSTEM

First exam evaluation evaluation (20%). -> Types of tests (10%) and Simulation (10%)
Evaluation of concept exercises throughout the course (20%). -> Four exercises (5% each)
Practical evaluation (20%). -> Simulations and modeling (5%) and in the laboratory (15%)
Project appraisal (20%). -> Exhibition (5%) Resolution and Results (15%)
Second exam evaluation test (20%). -> Test type (10%) and Simulation (10%)

Re evaluate all concepts in a theoretical examination of three hours.

BIBLIOGRAPHY

Basic:
- Mohan, Ned. Electric drives : an integrative approach. Minneapolis: MNPERE, 2003. ISBN 0966353013.
- Dubey, Gopal K. Fundamentals of electrical drives. 2nd ed. Pangbourne: Alpha Science, cop. 2001. ISBN 084932422X.
- Bose, Bimal K. Power electronics and motor drives : advances and trends [on line]. Oxford: Academic, 2006 [Consultation: 14/03/2024]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=270068. ISBN 0120884054.
- Miller, T.J.E. Brushless permanent-magnet and reluctance motor drives. Oxford: Oxford University Press, 1989. ISBN 0198593694.

Complementary:
- Ong, Chee-Mun. Dynamic simulation of electric machinery : using MATLAB/SIMULINK. Upper Saddle River, N.J: Prentice Hall, 1998. ISBN 0137237855.

RESOURCES

Hyperlink:
- http://www.iea.org/publications/freepublications/publication/EE_for_ElectricSystems.pdf />. http://www.iea.org/publications/freepublications/publication/EE_for_ElectricSystems.pdf

Other resources:
AL001