Course guide
240210 - 240EN37 - Control of Electrical Machines and Power Electronics

Last modified: 16/04/2024

Unit in charge: Barcelona School of Industrial Engineering
Teaching unit: 709 - DEE - Department of Electrical Engineering.

Degree: MASTER'S DEGREE IN ELECTRIC POWER SYSTEMS AND DRIVES (Syllabus 2021). (Optional subject).
MASTER'S DEGREE IN ENERGY ENGINEERING (Syllabus 2022). (Optional subject).

Academic year: 2024 **ECTS Credits:** 5.0 **Languages:** English

LECTURER

Coordinating lecturer: Bergas Jane, Joan Gabriel

Others: Bergas Jane, Joan Gabriel

PRIOR SKILLS

Power electronics: constituent elements and main structures.
Working principles of electric machines: mainly the direct current machine and the PMSM (Permanent Magnet Synchronous Motor).

TEACHING METHODOLOGY

Teaching will be 100% practical, developing the entire subject in the laboratory and through the use of:
- A small static converter
.- Its control, a DSP (Digital Signal Processor) from Texas Instruments that will be programmed with Simulink/Matlab.
.- A load that will be either a DC motor or a Brushless motor.

LEARNING OBJECTIVES OF THE SUBJECT

The main objective of the subject is to acquire the knowledge to be able to control converters and electrical machines. Therefore, at the end of the subject, students should be able to:

.- Identify all the elements that are part of the converters.
.- As well as knowing how they are controlled.
.- Understand the main control techniques of electrical machines.
.- Also acquire a deep knowledge of the modeling of electrical machines and power converters (with Simulink)
.- The programming of the DSP (Digital Signal Processor) that will control the converter-motor system, based on the previous Simulink model. (HIL Hardware in-the-loop).

STUDY LOAD

Type	Hours	Percentage
Hours small group	45,0	100.00

Total learning time: 45 h

CONTENTS

Introduction

Description:
content english

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

ACTIVITIES

Simulink simulation of a Step-down converter

Description:
This activity (which will last two sessions) we will introduce the way of working that will be followed throughout the subject:

1.- Simulate the step-down converter with Simulink, especially its control strategy, PWM (Pulse Width Modulation).
2.- Enter the hardware model of the converter in Simulink, using blocks provided by the manufacturer, such as the PWM outputs.
3.- Program the control system based on the previous Simulink model.
4.- Visualize with an oscilloscope the voltage waveforms that can be obtained with a PWM output.
5.- Connect a DC motor and observe how it behaves as different PWM parameters are changed.

Material:
.- MOSFETS static converter and its control
.- PC for the simulation, programming and debugging of the system.
.- Oscilloscope to visualize the waveforms.

Full-or-part-time: 9h
Laboratory classes: 9h

Control of a separately excited DC motor

Description:
1.- Simulation with Simulink of the Full-Bridge DC/DC Converter and DC motor set.
2.- Adaptation of the previous simulation to Hardware in-the-loop.
3.- Observe the operation of the converter-motor system based on different modifications to the control, and observe the problems presented by this control.

Material:
.- MOSFETS static converter and its control
.- PC for the simulation, programming and debugging of the system.
.- Oscilloscope to visualize the waveforms.
.- Separately excited DC motor

Delivery:
A document with the main results of the Simulink simulation of the converter-motor assembly.

Full-or-part-time: 9h
Laboratory classes: 9h

Current control loop.

Description:
This activity will consist of controlling the current flowing through the winding of an independent excitation DC motor. Based on the results of the previous activity, the following will be carried out:
.- Reading of the intensity that circulates through the winding. A Hall effect transformer will be used.
.- The control loop will be closed with a PID controller executed by the control system.
.- The response of the system to a current setpoint step will be adjusted, both in a purely experimental way and theoretically with the imposition of pulses.

Material:
.- MOSFETS static converter and its control
.- PC for the simulation, programming and debugging of the system.
.- Oscilloscope to visualize the waveforms.
.- Separately excited DC motor.
.- Hall effect current transformer.

Delivery:
A document with the main results of the Simulink simulation of thecurrent control loop and the tunning of the PID parameters.

Full-or-part-time: 9h
Theory classes: 9h

Determination of the angular position and speed of the axis of a motor using an encoder or resolver

Description:
.- The angular position of the brushless motor rotor will be measured with the help of an encoder.
.- The encoder will be connected to a special input of the control system that has implemented the reading of the encoder signals.
.- Several tests will be carried out and different parameters of the system will be adjusted, observing their effect on the measurement of the angular position.
.- A PLL (Phase Lock Loop) will be incorporated for filtering the encoder signals and obtaining the rotor speed.

Material:
.- MOSFETS static converter and its control
.- PC for the simulation, programming and debugging of the system.
.- Oscilloscope to visualize the waveforms of the encoder and/or the resolver.
.- PMSM with and encoder/resolver in its axis.

Full-or-part-time: 9h
Theory classes: 9h

Torque control a Brushless motor

Description:
.- Brushless motor modeling and simulation. Motor equations in Park's variables.
.- Simulation of the three-phase converter and its control. Generation of three-phase sinusoidal waves SVPWM (Space Vector PWM).
.- Three-phase current loops.
.- Torque control of the brushless motor.

Delivery:
A document will be delivered with the main results of the simulation with Simulink of the torque control of the brushless motor as well as the comparison with the same experimental results.

Full-or-part-time: 9h
Theory classes: 9h

GRADING SYSTEM

The final grade (FG) will be obtained from the grades of the small works that will be developed at the end of each of the activities (AG) and a final exam (FE), which will be developed in the same laboratory, and which will consist of carrying out some of the practices carried out during the course.

FG = 0.3 * AG + 0.7 * FE

BIBLIOGRAPHY

Basic:
- Krein, Philip T. Elements of power electronics. International second edition. New York: Oxford University Press, 2016. ISBN 9780199388424.
- Mohan, Ned [et al.]. Power electronics : converters, applications, and design. 3rd ed. New York [etc.]: John Wiley & Sons, cop. 2003. ISBN 0471226939.

RESOURCES

Audiovisual material:
- Nom recurs. Resource