COMILLAS
UNIVERSIDAD PONTIFICIA
ICAI ICADE CIHS

Syllabus
2022 - 2023

GENERAL INFORMATION

Data of the subject	
Subject name	Electric Drives
Subject code	DIE-GITI-432
Mainprogram	Bachelor's Degree in Engineering for Industrial Technologies
Involved programs	Grado en Ingeniería en Tecnologías Industriales [Fourth year]
Level	Reglada Grado Europeo
Quarter	Semestral
Credits	9,0 ECTS
Type	Optional
Department	Department of Electrical Engineering
Coordinator	FIDEL FERNANDEZ BERNAL
Schedule	A determinar por el profesor
Office hours	A determinar por el profesor

Teacher Information	
Teacher	
Name	Fidel Fernández Bernal
Department	Department of Electrical Engineering
Office	Alberto Aguilera 25
EMail	Fidel.Fernandez@iit.comillas.edu
Phone	2385
Teacher	
Name	Lukas Sigrist
Department	Instituto de Investigación Tecnológica (IIT)
EMail	Lukas.Sigrist@iit.comillas.edu
Profesores de laboratorio	
Teacher	
Name	Carlos Domingo Gil
Department	Department of Electrical Engineering
EMail	carlos.domingo@icai.comillas.edu
Teacher	
Name	Javier Herrero Fuerte
Department	Department of Electrical Engineering
EMail	j.herrero@icai.comillas.edu

Teacher	
Name	Luis Díez Maroto
Department	Department of Electrical Engineering
EMail	Luis.Diez@iit.comillas.edu

DESCRIPTION OF THE SUBJECT

Contextualization of the subject

Course contents

Contents

THEORY

Unit 1: Introduction to electric drives

1.1 What are they.

1.2 What are they for?

1.3 Industry examples.

Unit 2: Modeling of dynamic rotary mechanical systems

2.1 Introduction

2.2 Dynamic equation of rolling systems.

2.3 General scheme of analysis with rotating electrical machines.

2.4 Gears and pulleys.

2.5 Torsional resonance and electrical analogy.

2.6 Unitary system in mechanical systems.

Unit 3: Scalar speed control of induction motor

3.1 Introduction

3.2 Basics of induction machines.

3.3 Principles of constant flux control.

3.4 Areas of operation and limitations.

3.5 V/f control and voltage drop compensation.

3.6 Soft start.

3.7 Open loop and closed loop control schemes, slip compensation.

Unit 4: Scalar PWM and effects on the induction motor

4.1 Review of power electronics and switching elements.

4.2 Review of the operating principle of sinusoidal PWM, three-phase PWM.

4.3 Effects of the harmonics on induction motor and limitations.

Unit 5: Salient pole synchronous machines. dq steady-state representation.

5.1 Basics.

5.2 Saliency problematic.

5.4 Steady-state dq model.

Unit 6: Theory of space vectors in triphasic systems

6.1 Introduction.

6.2 Space vectors in triphasic systems: mathematical and graphical description.

6.3 Reference systems: Park transformation.

6.4 Air gap flux and induced voltage space vectors.

6.5 Space vector PWM.

6.6 Dynamic description of three-phase R-L systems.

6.7 General dynamic modeling of three-phase machines.

6.8 General torque production equation.

Unit 7: Dynamic modeling of synchronous machines

7.1 Dynamical model without damper windings: Permanent Magnet Synchronous Motor, Synchronous Reluctance Motor.

7.2 Modeling with damper windings.

7.3 Relationship with the steady-state model. Typical parameters.

Unit 8: Dynamic modeling of induction machines

8.1 Doubly-fed machine model.

8.2 Squirrel-cage machine model.

8.3 Relationship with the steady-state model.

Unit 9: Vector Control

9.1 General structure of control schemes.

9.2 Principle of the degree of freedom.

9.3 Vector control of the induction motor: direct and indirect control.

9.4 Vector control of the permanent magnet synchronous motor.

9.5 Vector control of the synchronous reluctance motor.

9.6 Use of DSP for the implementation of the control. A/D converters. Digital inputs/outputs.

9.7 The encoder as an element for measuring speed and position. Types. Schemes.

Unit 10: Current Control Design

10.1 Simplified models of machines with current control.

10.2 Inverter modeling.

10.3 PID schemes in dq representation.

10.4 Design of i/v decoupling regulators. Design examples.

Unit 11: Introduction to wind turbine control and FACTS

11.1 Control of wind turbines: topologies and basic schemes.

11.2 FACTS. The vector PQ control principle. Basic topologies. Basic control scheme.

Unit 12: Control of the DC and Brushless DC machine

12.1 Introduction.

12.2 Basic principles of the Brushless DC machine.

12.3 Equivalent model.

12.4 Speed control.

LAB

Experience 1: Introduction to Simulink and the simulation of rotating electrical machines.

Experience 2: Models of steady state vs. dynamic regime models

Experience 3: V/f control of the induction motor. Static characteristic simulation.

Experience 4: V/f control of the induction motor. Commercial equipment. Basic use.

Experience 5: V/f control of the induction motor. Commercial equipment. PWM and startup transients.

Experience 6: V/f control of the induction motor. Starting and braking ramp simulation.

Experience 7: V/f control of the induction motor. PWM simulation.

Experience 8: Transients in synchronous machine. qd representation and change of reference systems.

Experience 9: Transients in synchronous machine. Damping windings.

Experience 10: Vector control in induction machine. Current loop.

Experience 11: Vector control in induction machine. Speed loop.

EVALUATION AND CRITERIA

Evaluation activities	Evaluation criteria	Weight
Exams • Mid-term exam. • Final exam.	• Concepts asimilation. • Applying concepts to the resolution of practical problems. • Results interpretation. • Written communication skill.	65 %
Experimental work evaluation	Lab experiences • Critical analysis of the results obtained in laboratory practices. • Presentation and written communication. • Group work capacity. • Enthusiasm in carrying out the task. Lab exam • Ability to create dynamic simulation models. • Correct setting of simulation parameters. • Critical analysis of the results obtained. • Written communication skill.	35 %

Grading

Regular assessment

Final grade: 65% Theory + 35% Lab.

- **Theory** (out of 100%): 5% class grade, 70% final exam.
- **Lab** (out of 100%): 50% lab experiences, 50% practical exam. Practical exam grade should be at least 5 to pass lab.

Theory and lab grades should be at least 5 to pass the subject.

Retakes

The student has two periods of final evaluation during one academic year. The first one will be carried out at the end of course (end of the semester). In case that Theory or Lab were not passed obtaining 5 or more points, the student has another opportunity of final evaluation at the end of the academic year. The dates of evaluation periods will be announced in the web page. The new grade will by obtained as follows:

Retake grade: 65% Theory + 35% Lab.

- **Theory** (out of 100%): 5% class grade, 70% retake final exam.
- **Lab** (out of 100%): 50% lab experiences, 50% retake practical exam. Practical exam grade should be at least 5 to pass lab.

Theory and lab grades should be at least 5 to pass the subject.

Course rules

Class attendance is mandatory according to Article 93 of the General Regulations (Reglamento General) of Comillas Pontifical University and Article 6 of the Academic Rules (Normas Académicas) of the ICAI School of Engineering. Not complying with this requirement may have the following consequences: - Students who fail to attend more than 15% of the lectures may be denied the right to present the Theory or Lab final exams in regular assessment or retake period.

Students who commit an irregularity in any graded activity will receive a mark of zero in the activity and disciplinary procedure will follow (cf. Article 168 of the General Regulations (Reglamento General) of Comillas Pontifical University).

WORK PLAN AND SCHEDULE

Activities	Date of realization	Delivery date
Please, see document attached.		

BIBLIOGRAPHY AND RESOURCES

Basic References

- Novotny D. W., Lipo T. A., *Vector control and dynamics of AC drives*, Oxford University Press, 1996.
- Krause P.C., Wasynczuk O., Sudhoff S. D., *Analysis of electric machinery*, IEEE Press, 1995.