Control of electrical drives

Academic Year: (2023 / 2024) **Review date: 08-05-2023**

Department assigned to the subject: Electrical Engineering Department

Coordinating teacher: MONTILLA D'JESUS, MIGUEL EDUARDO

Type: Compulsory ECTS Credits : 6.0

Year : 4 Semester : 1

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

-Magnetic circuits and transformers
-Control Engineering
-AC Electric machines

SKILLS AND LEARNING OUTCOMES

CB1. Students have demonstrated possession and understanding of knowledge in an area of study that builds on the foundation of general secondary education, and is usually at a level that, while relying on advanced textbooks, also includes some aspects that involve knowledge from the cutting edge of their field of study.
CB2. Students are able to apply their knowledge to their work or vocation in a professional manner and possess the competences usually demonstrated through the development and defence of arguments and problem solving within their field of study.
COCIN1. Ability to draft, sign and develop projects in the area of industrial engineering for construction, renovation, repair, preservation, demolition, manufacture, installation, assembly or operation of: structures, mechanical equipment, energy installations, electrical and electronic installations, industrial plants and installations and automation and manufacturing processes.
COCIN4. Ability to resolve problems with initiative, decision-making, creativity, and critical reasoning skills and to communicate and transmit knowledge, skills and abilities in the Industrial Engineering field.
COCIN5. Knowledge to perform measurements, calculations, assessments, appraisals, surveys, studies, reports, work plans and other similar jobs.
CEP1. Capacity to design a system, component or process in the area of electrical engineering in compliance with required specifications.
CEP2. Knowledge and ability to apply computational and experimental tools for analysis and quantification of electrical engineering problems.
CEP3. Ability to design and carry out experiments to analyze and interpret data obtained.
CER4. Knowledge and use of the principles of electrical circuits and electric machinery theory.
ECRT1. Capacity for calculation and design of electric machinery.
ECRT2. Knowledge of machinery control and electrical drives and applications.

By the end of this content area, students will be able to have:
RA1.3. Coherent knowledge of the branch of electrical engineering including some at the forefront of their branch in electric machines.
RA2.1. The ability to apply their knowledge and understanding to analyse engineering products, processes and methods.
RA2.3. The ability to select and apply relevant analytic and modelling methods in electric machines and drives.
RA3.1. The ability to apply their knowledge and understanding to develop and realise designs to meet defined and specified requirements.
RA3.2. An understanding of design methodologies for electric power conversion, and an ability to use them.
RA4.2. The ability to design and conduct appropriate experiments, interpret the data and draw conclusions.
RA4.3. Workshop and laboratory skills.
RA5.1. The ability to select and use appropriate equipment, tools and methods for electric machines and drives.

RA5.2. The ability to combine theory and practice to solve electrical engineering problems.
RA5.3. An understanding of applicable techniques and methods in the design, analysis and selection of electric machines and drives, and of their limitations.

OBJECTIVES

-Ability to selection, analysis, and size of electric drives.

-To know the schemes of the electric motors speed control

-Ability to control an electric drive and simulate dynamic response

DESCRIPTION OF CONTENTS: PROGRAMME

LESSON 1. Introduction to electric drives and mechanical system
1.1) Introduction, Law of Motion for electric drives.
1.2) Basic principles of mechanics (moment-of-inertia, angular acceleration, gearbox, pulleys and flexible mechanical system)
LESSON 2. Introduction to DC machines and DC-DC converters
2.1) Principle of operation of the separately excited and series DC motors
2.2) Speed control of the separately excited and series DC motors (steady-state study)
2.2.1) Principles of speed control by varying applied voltage.
2.2.2) Principles of speed control by varying excitation flux.
2.3) Rectifier AC-DC power, controlled and uncontrolled.
2.4) Step-Down (Buck) and Step-up (Boost) converters
LESSON 3. DC Motor Drives
3.1) Operating principles in DC-motor drives (torque control, speed control, and flux control).
3.2) Speed control in the separately excited DC motor.
3.3) Dynamic Model of the DC motor
LESSON 4. AC Motor Drives (inverter)
4.1) Introduction to frond-end Inverter, Definition of Space vectors, Clarke transformation, and Park transformation. Inverter model in Stator Reference Frame.
4.2) Operating Principles of frond-end Inverter
4.3) Controller design for Inverter (space vector PWM)
4.4) Limits of the Inverter.
LESSON 5. Dynamic model of the induction motor and Scalar Speed Control
5.1) Dynamic model of the induction motor (cage rotor)
5.2) Scalar control of induction motors
LESSON 6. Vector control systems for induction motors
6.1) Introduction
6.2) Transformation of the dynamic model of the machine for vector control
6.2.1) Field Orientation Principle. Torque Control. Rotor flux Control.
6.2.2) Torque-speed characteristics for vector control. Rotor flux orientation.
6.2.3) Direct and indirect vector control
6.3) Direct vector control induction motor fed by converter which operates as a current source (torque, speed and flux control)
6.4) Direct vector control induction motor fed by converter which operates as a voltage source (torque, speed and flux control)

LEARNING ACTIVITIES AND METHODOLOGY

-The development of the course will be based on master classes with previous comprehensive reading of texts on some of the topics to be developed, individual tutorials. (3 ECTS credits).

-Lab practices. On the other hand, classes will be taught in the computer lab for students to develop through computer models (MATLAB / Simulink) all knowledge acquired on the DC and AC electric drives. Group and individual tutoring (3 ECTS credits)

ASSESSMENT SYSTEM

% end-of-term-examination:	60
% of continuous assessment (assigments, laboratory, practicals…):	40

A. ORDINARY SESSION
1.- Continuous assessment (EvC)
- Computer Test (50 %)

% end-of-term-examination: 60

% of continuous assessment (assigments, laboratory, practicals…): 40

- Homework's notes in small group (37,5%)
- Note of laboratory practice (12,5 %)

2.- Ordinary assessment (EvO)
3.- Final Note
-If the student PRESENTS ALL assigned homework (small group) with AVERAGE TOTAL NOTE ABOVE 3 and he/she is SUITABLE in the lab practices:
FINAL NOTE = 0,4*EvC + 0,6*EvO
FINAL NOTE = 0,4*EvC (if EvO is less than 3,5)

B. EXTRAORDINARY ASSESSMENT
1.- Continuous assessment (EvC)
- Computer Test (50 %)
- Homework's notes in small group (37,5%)
- Note of laboratory practice (12,5 %)

2.- Extraordinary assessment (EvE)
3.- Final Note (Maximum score obtained according to the following points a and b)
a) FINAL NOTE = EVE + Test lab additional if you did not attend any or all of the practices (EPLA)
b) Criteria to consider continuous assessment (EvC)
-If the student PRESENTS ALL assigned homework (small group) with AVERAGE TOTAL NOTE ABOVE 3 and
he/she is SUITABLE in the lab practices:
FINAL NOTE = 0,4*EvC + 0,6*EvE + EPLA

In either calls the conditions to pass the subject:
FINAL NOTE = > 5 (greater than or equal to 5)

(*) Marks obtained in the laboratory for the course for subsequent courses will not be saved. In the ordinary call, the note of practices will be greater than 5.

BASIC BIBLIOGRAPHY

- Chapman Stephen J Máquinas Eléctricas, McGraw Hill.
- Fitzgerald Arthur Eugene, Máquinas Eléctricas, McGraw Hill.
- Fraile Mora Jesús Máquinas Eléctricas, McGraw Hill.
- Krause Paul C Analysis of Electric Machinery, IEEE.
- Leonhard Werner Control of Electrical Drives. , Springer.
- Mohan Ned Power Electronic: converter, application and design, John Wiley & Sons.

ADDITIONAL BIBLIOGRAPHY

- Theodore Wildi Máquinas Eléctricas y Sistemas de Potencia, Prentice Hall.
- Trzynadlowski, Andrzej M. The Field Orientation Principle in Control of Induction Motors, Kluwer Academic Publishers.