Electric rotating machines

Academic Year: (2023 / 2024) **Review date: 27-04-2023**

Department assigned to the subject: Electrical Engineering Department

Coordinating teacher: RODRIGUEZ AMENEDO, JOSE LUIS

Type: Compulsory ECTS Credits : 6.0

Year : 3 Semester : 2

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Electric power engineering fundamentals (2nd year), Circuitos magnéticos y transformadores (4th year)

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.
ECRT2. Knowledge of machinery control and electrical drives and applications.
ECRT7. Applied knowledge of electronic power.

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

After having passed this subject, the student will be able to:
- Describe the operating principle and physical constitution of the different types of rotating electrical machiones used in industrial facilities
- Compute the numerical parameters of their equivalent circuits from standard tests
- Use the equivalent circuit to obtain quantitative and qualitative conclusions about the behaviour of ac rotating electrical machines under real operating conditions
- Define the safe operational limits of electrical machines
- Select and define the set of specificacions of any electrical rotating ac machine for each individual applications, from technical datasheets
- Justify the interactions of these machines with the balance of the electrical power system.

DESCRIPTION OF CONTENTS: PROGRAMME

1. General aspects of rotating electrical machines
1.1 Introduction.
1.2 Technologial aspects: degrees of protection, isolation, definition of rated power, heating and service classes.
1.3 Constructive aspects: Description of the various components of electrical machines.
1.4 Basic concepts of electromaghnetism: magnetic fields and electromotive forces applied to electrical machines

2 Synchronous machines.
2.1 Introduction. Physical constitution, cooling systems and excitation systems.
2.2 Principle of operation.
2.3 No-load and load operation. Armature reaction.
2.4 Equivalent circuit of a synchronous machine in saturated and unsaturated condition. Synchronpus impedance.
2.5 Standard tests: no-load, short-circuit and pure reactive load.
2.6 Calculation of the equivalent circuit parameters. Absolute and relative values. Short circuit ratio.
2.7 Determination of the excitation values in load mode.
2.8 Coupling to an infinete bus. Synchronization. Control of active and reactive power.
2.9 Stability limits in steady state.
2.10 Short-circuit current. Concept of subtransient and transient reactance.
2.11 Operational limits. Obtaining the operational limits chart in generator- and motor region.
2.12 Salient pole synchronous machines.
2.13 Motor operation, application and starting methods.

3. Asynchronous machine
3.1 Introduction. Constructive aspects and fundamentals.
3.2 Equivalent circuit. Description of the equivalent circuit of an asynchronous machine in steady state.
3.3 Power balance. Description of the balance of active and reactive power. Internal mechanical power and torque.
3.4 Mechanical characteristics. Deduction of the speed-torque curve and calculation of performance.
3.5 Standard tests on induction motors. No-load and short-circuit tests.
3.6 Starting methods. Direct-on-line, trnasformer, wye/delta, rotor resistances, electronic starters
3.7 Speed variation. Traditional methods of variation of speed and braking methods.
3.7 Asynchronous generator. Description of the machine in generator mode and applications.
3.8 Single phase ac motors. Description of single phase and Leblanc theorem.

4. Speed regulation of ac electrical machines.
4.1 Elements of a variable-frequency drive system.
4.2 Generation of PWM sinusoidal waves.
4.3 The equivalent circuit of the induction motor at variable frequency.
4.4 Scalar control. Constant flux (torque) range and variable flux (constant power) range.
4.5 Technological and practivcal aspects of variable speed drives.

LEARNING ACTIVITIES AND METHODOLOGY

1. TRAINING ACTIVITIES
1.1 Class lectures and numerical exercises in small groups, tutoring and student personal work; aimed at the acquisition of theoretical knowledge.
1.2 Laboratory sessions and computer simulation sessions, individual tutorials and student's personal work, oriented to the acquisition of practical and problem-solving skills related to the content of this subject.
1.3 The students will carry out a miniproject about selecting the elements of a facility involving an

electrical machine (starter, speed control, braking), in teams of up to three students.

2 TUTORIALS:
2.1 Individual tutorials: the schedule will be published at the beginning of the course.

ASSESSMENT SYSTEM

The calification of this subject is the weighted average of three activities:

1) Written exams induction machines (50% of the calification)
2) Written exams synchronous machines (50% of the calification)
3) Laboratory practices (must be passed to qualify the subject)

Written exams include theoretical questions and problems. During the course intermediate exams will be carried out that allow to elimitate parts from the final exam of the subject.

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

BASIC BIBLIOGRAPHY

- Charles A. Gross Electric Machines, CRC Press. Taylor & Francis Group. Boca Raton , 2007
- Vicent del Toro Basic Electric Machines, Prentice Hall.