ELECTRICAL MACHINES

Code: 322063

Main Scientific Area: Tecnologic innovation

Lecturer: Orlando Araújo Silva

Language of Instruction: Portuguese

Regime: S1

Contact Hours: 60h Total Workload: 108h

ECTS: 6,0

Objectives

The purpose of this curricular unit is to prepare the students with the fundamental knowledge in the area of electric machines, beginning with an approach of the fundamental general concepts that are transversal to the full range of the study area, and after make an individualized analysis of the main types of electric machines.

The students are leaded to understand the physical phenomenon's related to electric machines and for each one of the existing types the students should describe and analyze their equivalent circuits, their phasor diagrams and their characteristic curves.

As much as possible, practical application cases of the topics should be used, oriented for problem solving on the areas of design, use, commissioning and project of electric machines.

Learning Outcomes

Students who successfully complete this course should be able to:

1. Know and understand the use of electric machines in electrical systems;

2. Know the working principle of the transformers, as well as their equivalent circuits and constructive aspects;

3. Know the working principle of the direct current electric machines, as well as their equivalent circuits and constructive aspects;

4. Know the working principle of the alternate current electric machines, as well as their equivalent circuits and constructive aspects;

5. Understand the working regimes of the studied electric machines, in order to optimize the performance and use;

6. Able to project electric systems containing electric machines according to the defined requirements;

Course Contents

1. Introduction to electric machines

1.1. Electric machines in the electric systems

1.2. Basic AC concepts

1.2.1. Generation of AC current

1.2.2. Average, peak and RMS values

1.2.3. Electric power

1.2.4. Phasors

1.3. Magnetic circuits and energy conversion

1.3.1. Magnetic field production

1.3.2. Flux density (B), field intensity (H) and Permeability()

1.3.3. Magnetic circuits

1.3.4. Magnetization

1.3.5. Hysteresis and Foucault currents. Dispersion

1.3.6. Faraday Law and Lenz Law

1.4. Basic principles of rotating machines

1.4.1. Rotational movement (position, speed and angular acceleration)

1.4.2. Mechanic energy and power

1.4.3. Force and Torque equations

1.4.4. Power flow and losses

1.4.5. Voltage regulation and speed regulation

2. Transformers

2.1. The importance of transformers

2.2. Constructive aspects and transformer types

2.3. Ideal transformer

2.3.1. Power

2.3.2. Reflected impedance

2.4. Real single phase transformer

2.4.1. Transformer ratio

2.4.2. Magnetization current

2.4.3. Dot convention

2.5. Transformer equivalent circuit

2.5.1. Main characteristics

2.5.2. Open circuit test and short circuit test

2.5.3. Copper and iron losses

2.6. Three-phase transformers

2.6.1. Connection groups

2.6.2. p.u. system (“per unit”)

2.7. Transformer losses and efficiency

2.8. Autotransformers

3. DC Machines

3.1. Operating principles

3.2. Commutator action

3.3. Constructive aspects

3.4. Working equations

3.4.1. EMF equation

3.4.2. Torque equation

3.4.3. Speed equation

3.5. Equivalent circuit of a DC motor

3.6. The Magnetization Curve of a DC Machine

3.7. Separately Excited and Shunt DC Motors

3.8. The Permanent Magnet DC Motor

3.9. DC motor driving

4. Synchronous machines

4.1. Types and constructional features

4.2. Operation as generator

4.3. Operation as motor

4.4. Model of the synchronous machine

4.5. Fields of use of synchronous machines

5. Induction motors

5.1. Induction Motor Construction

5.2. Working principle

5.3. Working equations

5.4. The Equivalent Circuit of an Induction Motor

5.5. Power and Torque

5.6. Electromechanical and mechanical characteristics

5.7. Equivalent circuit parameters from test data

5.8. Starting Induction Motors

5.8.1. Squirrel cage motor

5.8.2. Wound-Rotor Motors

5.9. Speed Control of Induction Motors

5.10. Induction generator

6. Single-Phase and Special-Purpose Motors

6.1. Universal motor

6.2. Reluctance motor

6.3. Hysteresis motor

6.4. Stepper motors

6.5. Servomotors

6.6. Linear motors

7. Electric machinery drives

7.1. Operating regime

7.2. Control of AC and DC motors

7.3. Starting

7.4. Braking

7.5. Reversal

7.6. Electronic control of motors

7.7. Soft starters

7.8. Frequency Inverters

7.8.1. Selection

7.8.2. Wiring: command and power

7.8.3. Parameterization

7.8.4. Optimization

7.9. Sizing and project

Recommended Bibliography

• Syed A. Nasar (1998), Electric Machines and Electromechanics, 2nd ed., Mc-Graw Hill.

• Guru, B.S. and Hiziroglu, H.R. (2000), Elect. Mach. and Fund., 3rd Ed., Oxford Un.Press.

• Werner Leonhard (2001), Control of Electrical Drives, 3rd Edition, Springer

• Austin Hughes (2006), Electric Motors and Drives - Fundamentals, Types and Applic., Newnes

Learning and Teaching Methods

The study of electrical machines in this course includes the static and rotating machines, starting the analysis by the transformer, and passing successively by each major electrical machines mentioned in the syllabus, such as DC machines, asynchronous machines, synchronous machines and special motors.

In order to optimize the performance and use of each of the machines, are studied the control schemes, making whenever possible in laboratory tests and simulations of the respective actuators.

Particular emphasis will be given to electronic drives, through the implementation of integrated practical work, which will combine the various acquired knowledge.

Assessment Methods

The approval in this Curricular Unit is obtained by achieving a grade equal or superior to 10 (ten) points, on a 0 to 20 scale, as a result of the theoretical-practical component evaluation, by doing two written tests (25% + 25%) and a set of 3 practical works, elaborated during the semester (TP1 (15%) TP2 (15%) TP3 (20%)). The minimum grade for the written test is 9 (nine) points. The individual evaluation is mandatory for all practical work with a minimum grade of 10 (ten) points.