ELECTRICAL MACHINES

Code: 322063

Main Scientific Area: Automation, energy and cyber-physical systems

Lecturer: José Alberto Baère de Faria Campos Neves

Language of Instruction: Portuguese

Regime: S1

Contact Hours: 60h Total Workload: 100h

ECTS: 6,0

Objectives

This learning unit aims at providing students with fundamental knowledge in the field of electrical machines, starting with an approach to the main general and transversal concepts, to an individualized study of each type of electrical machines.

It is intended that students understand the physical phenomena related to electrical machines and, for each, describe and analyse their equivalent circuits, their phasor diagrams and their characteristic curves.

Whenever possible, the study will be based on practical use cases of real application, aimed at solving problems in the areas of conception, use, commissioning and design of electrical systems.

Learning Outcomes

Students who successfully complete this learning unit should be able to:

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

2. Know the operating principle of transformers, as well as their equivalent circuits and construction aspects.

3. Know the operating principle of direct current (DC) electrical machines, as well as their equivalent circuits and construction aspects.

4. Know the operating principle of alternating current (AC) electrical machines, as well as their equivalent circuits and construction aspects.

5. Understand the operating regimes of the studied electrical machines in order to optimize their performance and use. 6. Ability to design electrical systems with electrical machines based on defined requirements.

Course Contents

1. Introduction to electrical machines

1.1. Electrical machines in electrical systems

1.2. AC Basic Concepts

1.2.1. AC current generation

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, Field strength and Magnetic permeability

1.3.3. Magnetic circuits

1.3.4. Magnetization

1.3.5. Hysteresis and Eddy currents.

1.3.6. Faraday's Law and Lenz's Law

1.4. Basic principles of rotating machines

1.4.1. Rotational motion (position, velocity and angular acceleration)

1.4.2. Energy and mechanical power

1.4.3. Force and Torque Equations

1.4.4. Power flow and losses

1.4.5. Voltage and speed regulation

2. Transformers

2.1. Importance of transformers

2.2. Constructive aspects and types of transformers

2.3. Ideal transformer

2.3.1. Power

2.3.2. Reflected impedance

2.4. Single phase real transformer

2.4.1. Transformation relationship

2.4.2. Magnetizing current

2.4.3. Point convention

2.5. Transformer Equivalent Circuit

2.5.1. Main features

2.5.2. No-load and nominal load tests

2.5.3. Iron and Copper losses

2.6. Three-phase transformers

2.6.1. Link groups

2.6.2. p.u. system ("per unit")

2.7. Losses and performance of transformers

2.8. Autotransformers

3. Direct current (DC) machines

3.1. Operation principle

3.2. Switch (commutator) action

3.3. Constructive aspects

3.4. Operating equations

3.4.1. Electromotive force

3.4.2. Binary

3.4.3. Speed

3.5. DC Motor Equivalent Circuit

3.6. DC machine magnetization curve

3.7. Separately excited and shunt connection DC motors

3.8. Permanent magnet DC machines

3.9. DC motor drive

4. Synchronous Machines

4.1. Typology and construction aspects

4.2. Operation as generator

4.3. Operation as motor

4.4. Synchronous machine model

4.5. Areas of use of synchronous machines.

5. Induction Motors

5.1. Constructive aspects

5.2. Operation principle

5.3. Operating equations

5.4. Equivalent Circuit

5.5. Powers and Torque

5.6. Electromechanical and mechanical characteristics

5.7. Tests to determine model parameters

5.8. Starting induction motors

5.8.1. Squirrel Cage Motors

5.8.2. Wound rotor motors

5.9. Speed control in induction motors

5.10. induction generator

6. Single-phase motors and special motors

6.1. Universal engine

6.2. Reluctance Motor

6.3. Hysteresis Motor

6.4. Step Motors

6.5. Servo Motors

6.6. Linear Motors

7. Activation of electrical machines

7.1. Operating regimes

7.2. Control of AC motors and DC motors

7.3. Start-up

7.4. Braking

7.5. Rotation direction reversal

7.6. Electronic engine control

7.7. Soft starters

7.8. Speed variators

7.8.1. Selection

7.8.2. Control and power connections

7.8.3. Parameterization

7.8.4. Optimization

Recommended Bibliography

• Stephen J. Chapman, Fundamentos de Máquinas Elétricas 5ª Edição, Mc-Graw Hill.

• Allan H. Robbins and Wilhelm C. Miller, Circuit Analysis: Theory and Practice, 3rd Edition

• 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 Applications, Newnes.

Learning and Teaching Methods

The study of electrical machines in this learning unit comprises static and rotating machines, starting with the transformer, and successively going through each of the main electrical machines mentioned in the programme content, such as direct current machines, asynchronous machines, synchronous machines and special motors.

In order to optimize the performance and use of each machine, control schemes are studied and carrying out laboratory tests and simulations of the respective drives whenever possible. Emphasis will be given on electronic drives via a practical work where the multiple transverse acquired knowledge will be combined.

Assessment Methods

Approval in this learning unit will be achieved with a grade equal or greater than 10 (ten) points, on a scale of 20 points, resulting from the evaluation of the theoretical-practical component, through the completion of a written test (50%) and a set of 2 practical assignments, carried out during the semester (TP1=25% and TP2=25%). The minimum grade for the written test is 9 (nine) points. The mandatory individual assessment of each practical component will have a minimum score of 10 (ten) values.