UNIVERSITÀ DI PAVIA

Anno Accademico 2017/2018

DESIGN AND TECHNOLOGY OF ELECTRICAL MACHINES AND DRIVES

Enrollment year	2017/2018
Academic year	2017/2018
Regulations	DM270
Academic discipline	ING-IND/32 (POWER ELECTRONIC CONVERTERS, ELECTRICAL MACHINES AND DRIVES)
Department	DEPARTMENT OF ELECTRICAL,COMPUTER AND BIOMEDICAL ENGINEERING
Course	ELECTRICAL ENGINEERING
Curriculum	Energetica
Year of study	1°
Period	2nd semester (05/03/2018 - 15/06/2018)
ECTS	6
Lesson hours	48 lesson hours
Language	Italian
Activity type	ORAL TEST
Teacher	FROSINI LUCIA (titolare) - 6 ECTS
Prerequisites	The students of this course are required to possess or acquire adequate initial training on the following knowledge: electrical circuits, three-phase electrical systems, rotating magnetic field, operating principles of the main electrical machines (transformer, induction machine, synchronous machine).
Learning outcomes	The course aims to provide students with an in-depth knowledge of the operation and construction aspects of the main electrical machines (transformer, brushed DC machine, induction machine, synchronous machine) and basic knowledge of permanent magnet synchronous motors and variable reluctance machines. At the end of the course, students should be able to provide the general criteria for sizing these electrical machines, on the basis of the optimal exploitation of the materials used in their construction and with respect to the performance

required in the electrical systems.

Course contents

1. Magnetic, conducting and insulating materials
Hard and soft magnetic materials, hysteresis and eddy currents losses, laminations of grain-oriented silicon-iron. Skin effect in the conductors. Characteristics of the insulating materials (gaseous, liquid and solid), dielectric rigidity, partial discharges, thermal classes.

2. Transformer
Construction aspects: core, windings, cooling systems. Sizing formula and design criteria. Angular groups. Short circuit transient in a transformer. Transient transformer inrush current. Calculation of the leakage inductance of a cylindrical winding in a transformer. Calculation of the Lorentz forces in case of short circuit in a transformer. Shell-type transformers. Accessories of the oil-insulated transformers. Zigzag connection.

3. Brushed DC machine
Main construction aspects. Wave and lap windings for the rotor. Magnetic fluxes produced by the main field and by the armature reaction. Operation of the commutator machine as a motor: induced electromotive force, expression of the torque. Separately excited motor, series motor, universal motor. The ideal commutation and the commutation with inductive phenomena: commutation poles. Saturation due to the armature reaction: compensation windings. Further construction aspects. Losses in the commutator motor.

4. AC windings
Types of AC stator windings: concentric and lap, single and double layer, full pitch and short pitch. Examples of realization of stator windings. Magneto-motive forces produced by the windings.

5. Induction machine
Equivalent circuit of the induction motor, power balance, electromagnetic torque, electromechanical characteristics, circle diagram. Construction aspects and types of rotor. Double cage and deep bar rotor. Parasitic torques and effects of the short pitch. International standards for the efficiency and methods for its improvement. Starting methods. The induction generator and outline on the DFIG. Sizing of a three-phase induction motor.

6. Synchronous machine
Operation of the synchronous generator: at no-load and in parallel with the grid. Armature reaction. Expression of the electromagnetic torque. Regulation of the active and reactive power. Construction aspects: rotor (smooth and with salient poles), damper windings, stator core and winding, excitation systems, cooling systems. Construction problems and solutions for the high power synchronous generators. Determination of the synchronous impedance. Capability curves. Synchronous motor and V-curves.

7. Permanent magnet synchronous motor (PMSM) and other special machines

	Operating principles with square wave (DC brushless) and sinusoidal wave (AC brushless) control techniques. Torque/speed curves. Cogging and ripple oscillating torques. Construction characteristics: internal, external or axial-flux rotor; surface (SPM) and interior (IPM) permanent magnets; materials for permanent magnets. Outline on the variable reluctance machines and on the line start permanent magnet motor.
Teaching methods	The course is organized by means of frontal lessons, featured through PowerPoint presentations, and insights using the blackboard. The PowerPoint presentations allow to show many images of electrical machines and parts of them, useful for reaching the course objectives. The exercises consist of the presentation of the sizing procedure of some electrical machines, with numerical values specific to certain applications. During the course, some materials and parts of electric machines are also presented in the classroom. Finally, the training activities are completed by some seminars held by technical personnel, with a remarkable industrial competence, and with a technical visit in a high power electrical machine manufacturer firm. Lectures (hours/year in lecture theatre): 42 Practical class (hours/year in lecture theatre): 6
Reccomended or required readings	The presentations in PowerPoint and other documents, prepared and used by the teacher during the course, are available for the students in PDF format via KIRO website. This documentation is sufficiently detailed to form the reference text of the course. For further details, the following texts can be consulted: - Nicola Bianchi, Silverio Bolognani: “Metodologie di progettazione delle macchine elettriche”, CLEUP, 2001 (in Italian). - J.R. Hendershot Jr., TJE Miller, “Design of brushless permanent-magnet motors”, Oxford University Press, 1995.
Assessment methods	The exam consists of an individual oral test to assess the skills acquired in relation to the content of the course. The test focuses on at least three distinct topics related to different electrical machines handled during the course. The final evaluation is based on the degree of understanding of the topics presented and the ability to integrate the knowledge gained during the course.
Further information	The exam consists of an individual oral test to assess the skills acquired in relation to the content of the course. The test focuses on at least three distinct topics related to different electrical machines handled during the course. The final evaluation is based on the degree of understanding of the topics presented and the ability to integrate the knowledge gained during the course.
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