EECE 123
Fall 1999

EECE 123: Electromechanical Energy Conversion

Course Description:
Application of electromagnetic field and circuit theory to electromechanical energy conversion systems. Solutions for the magnetic fields, electromagnetic and electrostatic induced forces, and equivalent circuits using conservation of energy principles applied to electromagnetic, electrostatic-type electromechanical energy conversion devices.

Prerequisites: EECE 121 with a minimum grade of C

Course Materials:
Required: Kingsley A. Fitzgerald, & Umans, Electric Machinery, McGraw-Hill, 1990.

Course Goals:
- Understanding and use of Ampere’s Law in magnetic circuits in the presence of a complex mix of ferromagnetic (linear and nonlinear) materials side-by-side with nonmagnetic materials (air, insulation or free space), including effects of magnetizing windings, in calculating magnetic field intensities, flux densities, flux, flux linkages, and winding inductances.
- Understanding and use of the concepts of magnetomotive force, reluctance and permeance in the computation of flux magnitudes and space distributions, including understanding concepts of winding flux linkage, inductance and energy.
- Understanding concepts of AC excitation and associated effects such as induced eddy currents and eddy current losses as well as hysteresis losses in laminated and nonlaminated iron cores.
- Understanding concepts of permanent magnet excitation in magnetic circuits.
- Understanding the use of the above magnetostatic field analysis techniques in computing flux, flux density, induced emf in singly excited and multiply excited magnetic circuits with motion, including the presence of permanent magnets in electric machines.
- Understanding the computation of forces and torques in magnetic field devices and systems involving mixed air-iron regions.
- Understanding determination of magnetically produced mechanical forces from energy/coenergy concepts.
- Understanding the analysis of singly excited systems.
- Understanding the analysis of multiply excited systems.
- Understanding elementary concepts of AC and DC machine components.
- Understanding of mmfs of distributed windings.
- Understanding of stationary and traveling magnetic fields in rotating machinery.
- Understanding and computation of rotating magnetomotive forces in AC machines.
- Understanding and computation of induced/generated voltages in windings of AC and DC machines.
- Understanding determination of torque from energy/coenergy field concepts in rotation machines of the non-salient-pole-type, and reluctance salient-pole-type.
- Understanding of operation and forces in linear motion machines.
- Understanding complications resulting from magnetic saturation and leakage fluxes in electric machinery.
- Understanding the basic principles of operation of polyphase induction machines.
- Understanding currents, mmfs, and fluxes in induction machines.
- Understanding the nature of the equivalent circuit of a polyphase induction motor.
- Understanding analysis of the performance of the polyphase induction motor using its equivalent circuit.
- Understanding polyphase induction motor torque, power and efficiency calculations in power electronically controlled adjustable speed drives.
- Understanding the link between the equivalent circuit model and the magnetic field model of polyphase induction motors in electromagnetic torque calculations.
- Understanding currents, mmfs and fluxes in brush-type DC machines including commutation.
- Understanding analytical fundamentals of magnetic circuit and electric circuit modeling of DC machines.
- Understanding the analysis of the performance of DC machines under steady state conditions for separately, shunt, series, and compound excited DC motors.
- Understanding operation and analysis of DC motors in power electronically controlled adjustable speed

drives.

- Understanding currents, mmfs, fluxes and torque production in brushless-type DC machines.
- Understanding the analysis of the performance of brushless-type DC machines in adjustable speed drives.
- Understanding currents, mmfs, fluxes and torques in polyphase synchronous machines.
- Understanding the nature of the equivalent circuit of a polyphase synchronous machine and its relation to its magnetic field/magnetic circuit model of mmfs and fluxes.
- Understanding analysis of the performance of the polyphase cylindrical-rotor synchronous machine from its equivalent circuit model.
- Understanding polyphase synchronous motor torque, power and efficiency calculations in power electronically controlled adjustable speed drives.
- Understanding the basic constructional features and operation of single-phase AC induction-type and AC-commutator-type motors.
- Understanding the operation of single-phase AC-induction-type and AC-commutator-type motors.
- Understanding of the operation of single-phase AC-induction-type and AC-commutator-type motors in electronically controlled adjustable speed drives.

Course Objectives:

By the end of this course, the student should....

- Be able to compute the magnetomotive forces and flux distributions and induced electromotive forces associated with windings in AC polyphase-induction machines. AC polyphase-synchronous machines, DC brush-type and brushless-type machines, as well as other devices of similar nature.
- Be able to compute input power, output power, losses, efficiencies and torques in AC polyphase-induction and synchronous machines, as well as in brushless and brush-type DC machines, and other devices of similar nature.
- Be able to compute equivalent circuit parameters from physical geometries and design particulars of AC and DC machines.
- Be able to compute torque-speed characteristics and other related motor performance for AC induction and synchronous motors, as well as DC brush and brushless motors in adjustable speed drives.
- Be able to relate equivalent electric circuit parameters and their calculations to electromagnetic field qualities and phenomenon in the magnetic circuits of electromechanical energy conversion devices.
- Be able to properly select motors and generators for a given practical engineering application and carry out the necessary performance assessment computations.

Course Topics:

Magnetic Circuits and Magnetic Materials
Electromechanical Energy Conversion Principles
Basics of Power Electronic Energy and Power Conditioning for Electric Motors and Generators
Basic Concepts of Rotating Electric Machines
Polyphase AC Induction Machines
Brush-type and Brushless-Type DC Machines
Polyphase AC Synchronous Machines
Single-phase AC Induction, Commutator-
Type and Other Special Machines
Modern Trends in State-of-the-Art
Developments in Electric Machines and Drives

Class Schedule: 3 Credit course, meeting the equivalent of 3-50 minute class periods per week.

Contribution to Professional Component: Engineering Science 80%
Engineering Design 20%

Contribution to Program Objectives: partial fulfillment of Criterion 3 objectives A, B, C, E, G, I , K, L

Prepared by: Nabeel A. O. Demerdash January 10, 1999
Course Coordinator: Nabeel A. O. Demerdash

Last modified: July 13, 2000

EECE 123: Electromechanical Energy Conversion
ABET Objectives, Assessment Instruments,
and Assessment Criteria

(A) An ability to apply knowledge of mathematics, science, and engineering.
Demonstrated competence in prerequisite course work when applied to EECE 123

from MATH 082	Understanding differential and integral calculus as well as vectors in two and three dimensional space.
from EECE 121	Understanding electric and magnetic fields, and in particular Ampere's law, Biot-Savart law, magnetic materials and concepts of flux, flux density, flux linkage, energy and inductance in the presence of magnetic materials.
from EECE 012	Understanding of sinusoidal steady state electric circuit analysis with phasors, including three-phase balanced circuits, as well as computation of real and reactive power and power factor.

Tests and homework will demonstrate competence in most areas. A computer simulation of systems of adjustable speed drives using FORTRAN or another high level language in a project will demonstrate competence in the use of numerical methods. Minimum competence in test, homework and project depends on the student's relative standing in the class with a tolerance dependent on the overall grade distribution.

(B) An ability to design and conduct experiments, as well as to analyze and interpret data.
Complex computer simulation project of motors in adjustable speed drives, with students working in teams

(C) An ability to design a system to meet desired needs.
A design component in the complex computer simulation project - See (B).

(E) An ability to identify, formulate, and solve engineering problems.
Demonstrate competence in course material by solving assigned homework from textbook and as supplied by instructor. Tests and homework will demonstrate such competence, with minimum competence defined as given above in (A).

(G) An ability to communicate effectively.
Demonstrate competence in communicating qualitative explanations of various performance phenomena and characteristics in electric machines and drives, as well as in complex simulation project report.

(I) The recognition of the need for and ability to engage in life-long learning.
Demonstrate awareness of recent developments and possible future trends in the state of the art of electric machines and drives and of the professional society publications dealing with such aspects.

(K) An ability to use the techniques, skills and modern engineering tools necessary for engineering practice.
Complex computer simulation project will introduce students to a variety of such tools. This simulation includes use of state-space techniques to solve systems of differential equation governing the performance of machines and drives.

(L) An ability to apply probability and statistics and higher mathematics to the solution of engineering problems.
See (K) above.

Evaluation of Objective Attainment - Continuing Course Review

At the end of each semester, instructors of this course will submit a short written report to the Course Coordinator for EECE 123 which

a) discusses their perceptions of student knowledge and ability to apply the listed prerequisites, and
b) provides qualitative and quantitative information which discusses the attainment of objectives listed above for EECE 123

The Course Coordinator will review these reports with the instructors and in consultation with the instructors recommend modifications and/or enhancements to the objectives and criteria as needed. The recommendations will be forwarded to the EECE Undergraduate Committee for approval.

Last modified: July 13, 2000