The University Of Sheffield.

Electronic & Electrical Engineering.

EEE6200 AC MACHINES

Credits: 15

Course description including aims

1. To introduce the principle of operation of conventional AC machines.
2. To provide an insight into the operating characteristics of synchronous and induction machines.
3. To introduce the principle of operation of synchronous and switched reluctance machines, and discuss their operating characteristics.

Outline syllabus

Introduction to AC machines: magnetic circuits, properties of soft magnetic materials, flux linkage, inductance and energy, determination of forces and torques. **Polyphase rotating machines:** two-axis three-winding machine, general multi-winding machine, matrix form, electromagnetic torque, synchronous machine topology, induction machine topology, phase and dq axis transformations. **Sinusoidal windings:** single layer windings, double layer windings, fractional-slot windings. **Synchronous machines:** modeling and equivalent circuits, steady state and transient performance and operating characteristics of non-salient pole machines, effects of rotor saliency and steady state operating characteristics of salient pole machines. **Induction machines:** modeling and equivalent circuits, steady state and transient performance and operating characteristics. **Synchronous reluctance machines:** principle of operation, modeling and equivalent circuits, steady state and transient operating characteristics. **Switched reluctance machines:** principle of operation, steady state and transient performance and operating characteristics.

Time allocation

36 lectures.

Recommended previous courses

First degree or equivalent in Electronic and Electrical Engineering

Assessment

3-hour examination, answer 4 questions from 6.

Recommended books

Say M. G. *ALTERNATING CURRENT MACHINES* (Longman Scientific & Technical)
Nasar S. A. *ELECTROMECHANICS AND ELECTRIC MACHINES* (John Wiley & Sons)
Jones C. V. *THE GENERALISED THEORY OF MACHINES* (Butterworths)
Miller T. J. E. *SWITCHED RELUCTANCE MOTORS AND THEIR CONTROL* (Magna Physics Publishing)

Objectives

By the end of this module successful students will be able to:

1. Demonstrate an understanding of the principle of operation of conventional synchronous and induction machines.
2. Demonstrate an understanding of the modelling techniques employed in synchronous and induction machines.
3. Predict and demonstrate an understanding of the steady state and transient operating characteristics of conventional synchronous and induction machines.
4. Demonstrate an understanding of the principle of operation of synchronous and switched reluctance machines.
5. Predict and demonstrate an understanding of the steady state and transient operating characteristics of synchronous and switched reluctance machines.

Detailed Syllabus

1, 2, 3: Magnetic potential; magnetomotive force (mmf); magnetic reluctance and permeance; Ampere's law applied to magnetic circuits; ideal magnetic circuits; saturation of magnetic materials; leakage and fringing flux; examples of magnetic circuits.

4, 5, 6: Types soft magnetic materials; initial magnetisation and hysteresis curves; iron losses in laminated soft magnetic materials under AC excitations; effects of flux density harmonics; limitations of iron losses models.

7, 8, 9: Two-axis three winding machine; general multi-winding machine; matrix form; electromagnetic torque.

10, 11, 12: Synchronous machine topology; induction machine topology; phase and dq axis transformations.

13, 14, 15: Single layer windings; double layer windings; fractional-slot windings, winding factors.

16, 17, 18: Principle of operation synchronous machines; modelling and equivalent circuits; steady state motoring and generating characteristics of non-salient pole synchronous machines;

19, 20, 21: Steady state motoring and generating characteristics of salient pole synchronous machines; losses in synchronous machines; electrical transients in synchronous machines; mechanical transients in synchronous machines.

22, 23, 24: Principle of operation 3-phase induction machines; modelling and equivalent circuits; motoring and generating characteristics of induction machines; losses in inductions machines.

25, 26, 27: Principle of operation 1-phase induction machines; modelling and equivalent circuits; motoring and generating characteristics of induction machines; losses.
.**28, 29, 30:** Principle of operation of synchronous reluctance machines; modelling and equivalent circuits; steady state motoring and generating characteristics of synchronous reluctance machines; Losses in synchronous reluctance machines.

31, 32, 33: Principle of operation of switched reluctance machines; ψ-i diagrams, modelling of switched reluctance machines. Numbers of phases and poles of switched reluctance machines; steady state performance of switched reluctance machines; dynamic operation of switched reluctance machines; losses in switched reluctance machines.

34, 35, 36: Reading/contingency week.

UK-SPEC/IET Learning Outcomes

Outcome Code	Supporting Statement
SM1p	The fundamental principles of electromechanical energy conversion are introduced, and applied to AC machine topologies.
SM2m	The modelling techniques and the mathematical tools required for the determination of the performance of AC machines are introduced and demonstrated through examples. Furthermore, different approximations associated with the various operating conditions are discussed.
EA1m	The application magnetic/electric circuit principles for the development of equivalent circuit models for the different AC machines topologies. Furthermore, The types and properties of soft magnetic materials employed in the construction of AC machines are introduced and discussed.
EA2m	Analytical equations relating the main parameters and inputs/outputs of AC electrical machines are derived and discussed.
EA1fl	Interactions between the AC machines and their prime-movers/loads and electrical supply will be introduced, and effects of different load types on the operational stability of the electromechanical system are discussed.
D1fl	Mathematical models of varying degrees of fidelity are introduced, and the effects of the various approximations are discussed. In addition, methods of estimating the effects of the uncertainties in the values of the parameters of the electrical machines will be introduced.
D3m	Mathematical models of varying degrees of fidelity are introduced, and the effects of the various approximations are discussed. In addition, methods of estimating the effects of the uncertainties in the values of the parameters of the electrical machines will be introduced.