Engineering Tripos Part IB, 2P5: Electrical Power, 2022-23

Course Leader

Prof A J Flewitt [1]

Lecturer

Dr T Coombs [2]

Timing and Structure

Weeks 1,3,5 & 7 Lent term, 2 lectures/week; weeks 2,4,6 & 8 Lent term, 1 lecture/week. 10 lectures + 2 examples classes

Aims

The aims of the course are to:

- Introduce the student to the principal types of electromechanical energy conversion device (induction motor, synchronous machine) as well as to the transmission and distribution of a three-phase power system.

Objectives

As specific objectives, by the end of the course students should be able to:

- Understand why three-phase systems are used universally for bulk power transfer.
- To analyse balanced three-phase circuits
- Understand the principles of per-unit calculation.
- Perform basic calculations on balanced three-phase loads, including symmetrical three-phase short-circuits.
- Understand the form and construction of synchronous generators, induction machines.
- Understand the synchronous generator phasor diagram and operating chart, and be able to carry out performance calculations using either.
- Understand the effects of torque control and excitation control on the behaviour of a synchronous generator.
- Carry out performance calculations on the induction motor, using the per-phase equivalent circuit.
- Understand the factors controlling the shape of the induction motor torque/speed curve.

Content

The functioning of modern industrial society depends heavily upon the ready availability of energy in a form that can be transported cheaply and converted easily into other forms. The advantages of electricity make it the overwhelming choice as the medium of transportation. The processes by which electricity is generated and the means by which it is reconverted into mechanical energy for industrial uses are therefore of fundamental importance.

Three-phase systems (2L)

- Star and delta-connected loads and sources.
- Star-delta transformation.

- Single phase representation.
- Solution of balanced three-phase circuits including mixed loads.
- Power factor correction.

Generation (2L)

- Prime energy sources.
- Constraints on power systems.
- Basic principles of a.c. generators.
- Comparative utility of single-phase and three-phase .
- Production of a rotating magnetic field by a three-phase winding.
- Development of synchronous machine equivalent circuit.

Synchronous Generators (2L

- Phasor diagrams.
- Operation as a motor.
- Operation as a generator.
- Power and reactive power control.
- Operating chart.

Transmission and Distribution (2L)

- Per-unit system.
- Symmetrical three-phase faults.

Induction Motors (2L)

- Principles of operation
- Derivation of equivalent circuit.
- Construction.
- Performance predictions using equivalent circuit.
- Torque/speed characteristics and control of rotor resistance to vary them.

Booklists

Please refer to the Booklist for Part IB Courses for references to this module, this can be found on the associated Moodle course.

Examination Guidelines

Please refer to Form & conduct of the examinations [3].

UK-SPEC

This syllabus contributes to the following areas of the UK-SPEC [4] standard:

Toggle display of UK-SPEC areas.

GT1

Develop transferable skills that will be of value in a wide range of situations. These are exemplified by the Qualifications and Curriculum Authority Higher Level Key Skills and include problem solving, communication, and working with others, as well as the effective use of general IT facilities and information retrieval skills. They also include planning self-learning and improving performance, as the foundation for lifelong learning/CPD.

IA1

Apply appropriate quantitative science and engineering tools to the analysis of problems.

IA3

Comprehend the broad picture and thus work with an appropriate level of detail.

KU1

Demonstrate knowledge and understanding of essential facts, concepts, theories and principles of their engineering discipline, and its underpinning science and mathematics.

KU2

Have an appreciation of the wider multidisciplinary engineering context and its underlying principles.

E1

Ability to use fundamental knowledge to investigate new and emerging technologies.

E2

Ability to extract data pertinent to an unfamiliar problem, and apply its solution using computer based engineering tools when appropriate.

E3

Ability to apply mathematical and computer based models for solving problems in engineering, and the ability to assess the limitations of particular cases.

P1

A thorough understanding of current practice and its limitations and some appreciation of likely new developments.

P3

Understanding of contexts in which engineering knowledge can be applied (e.g. operations and management, technology, development, etc).

US1

A comprehensive understanding of the scientific principles of own specialisation and related disciplines.

US3

An understanding of concepts from a range of areas including some outside engineering, and the ability to apply them effectively in engineering projects.

US4

An awareness of developing technologies related to own specialisation.

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