Engineering Tripos Part IIA, 3B3: Switch-mode Electronics, 2018-19

Module Leader

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Lecturer

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Timing and Structure

Michaelmas term. 2 lectures/week.

Prerequisites

2P5

Aims

The aims of the course are to:

- Introduce power electronics and some of its main applications (power conversion in renewable energy, electric vehicles, smart grids)
- Introduce typical topologies for AC-DC, DC-DC and DC-AC power conversion
- Give basic and useful skills in analysing and designing power electronics based power converters

Objectives

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

- Know the characteristics of the diode and how to use diodes in rectifier circuits to obtain d.c. from single and three-phase a.c.
- Know how to reduce ripple using smoothing circuits.
- Know the characteristics of the thyristor and how to use the thyristor in controlled rectifiers operating from single or three-phase supplies.
- Be able to explain the conditions under which inversion, i.e. the flow of power from the d.c. to the a.c. side, takes place.
- Appreciate the relative merits of MOSFETs, IGBTs and bipolar transistors as switches.
- Be aware of the principal types of converter circuit and their characteristics.
- Know the principle of pulse-width modulation and simple ways of generating pulse-width modulated

waveforms.
- Be familiar with three-phase inverter circuits using pulse-width modulation.
- Be familiar with the essential elements of a complete switch-mode power supply.
- Be able to analyse the operation of a simple SMPS.
- Describe the various losses and estimate the efficiency of a Power Electronic System.
- Appreciate the role of power electronic converters in various applications.

Content

- The diode; simple rectifier circuits using diodes. Three-phase rectification. Smoothing circuits and waveform distortion. Regulated supplies using linear circuit techniques.
- The thyristor. Controlled rectification and inversion using thyristors.
- The MOSFET, IGBT and bipolar transistor as power switches.
- Basic switching converter configurations: the up and down converters. The concept of pulse width modulation; the generation of pulse-width modulated waveforms. Converters with isolation. Introduction to magnetics and components.
- Power losses in converters. ZCS and ZVS Resonant converters.
- Outline design for a complete switch-mode power supply including power factor correction.
- Half and full bridge circuits, Deadtime and the problem of the high side drive. The application of chopper circuits in DC motor drives.
- Single phase and three-phase inverter circuits. Variable voltage variable frequency three-phase inverter for use in induction motor drives.
- Transient Analysis in circuits.

Examples papers

4 examples papers issued at 2 week intervals to coincide with the lecture material.

Coursework

Switch-Mode Electronics

Learning objectives:

- Phase angle control of thyrister based AC-DC rectifier
- Thyrister based AC-AC converters
- Line-commutated converter (LCC) based HVDC

Practical information:

- [redacted]
- Self-learning notes will be given

Full Technical Report:

Students will have the option to submit a Full Technical Report.

Booklists

Please see the Booklist for Part IIA Courses [2] for references for this module.

Examination Guidelines

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

UK-SPEC

The UK Standard for Professional Engineering Competence (UK-SPEC) [4] describes the requirements that have to be met in order to become a Chartered Engineer, and gives examples of ways of doing this.

UK-SPEC is published by the Engineering Council on behalf of the UK engineering profession. The standard has been developed, and is regularly updated, by panels representing professional engineering institutions, employers and engineering educators. Of particular relevance here is the 'Accreditation of Higher Education Programmes' (AHEP) document [5] which sets out the standard for degree accreditation.

The Output Standards Matrices [6] indicate where each of the Output Criteria as specified in the AHEP 3rd edition document is addressed within the Engineering and Manufacturing Engineering Triposes.

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Links
[1] mailto:tl32t@cam.ac.uk
[2] https://www.vle.cam.ac.uk/mod/book/view.php?id=364091&chapterid=46311
[3] http://teaching.eng.cam.ac.uk/content/form-conduct-examinations
[4] http://www.engc.org.uk/ukspec.aspx
[5] http://www.engc.org.uk/standards-guidance/standards/accreditation-of-higher-education-programmes-ahep/
[6] http://teaching.eng.cam.ac.uk/content/output-standards-matrices