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

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.

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.

US2

A comprehensive knowledge and understanding of mathematical and computer models relevant to the engineering discipline, and an appreciation of their limitations.

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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] https://teaching.eng.cam.ac.uk/content/form-conduct-examinations
[4] https://teaching.eng.cam.ac.uk/content/uk-spec