

## **Engineering Tripos Part IIA, 3B3: Switch-mode Electronics, 2020-21**

### **Module Leader**

[Dr T Long](#) [1]

### **Lecturer**

Dr T Long

### **Lecturer**

Prof Florin Udrea

### **Lab Leader**

Dr T Long

### **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 (PLECS modelling)

### **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 aware of the principal types of converter circuit and their characteristics.
- Understand the principle of pulse-width modulation and simple ways of generating pulse-width modulated waveforms.
- Understand working principle of three-phase inverter circuits using pulse-width modulation.

- Be familiar with the
- Be familiar with the passive components (inductor and capacitor) used in power electronic systems
- Appreciate the relative merits of MOSFETs, IGBTs and bipolar transistors as switches.
- Describe the various losses and estimate the efficiency of a Power Electronic System.
- Gain skills of power electronic system modelling (PLECS)
- Conduct basic tests of power electronic systems and use digital oscilloscope, pulse generator, probes and be familiar with typical power electronic and passive component devices and packages in real systems(Lab)

## Content

**This module will also introduce PLECS modelling, all module students are offered free license (full function) of PLECS for 12 months.**

Lecture 1: Introduction of power electronic systems and their applications, common math and physics used in analysing power electronic systems

- Non-isolated DC-DC converter

Lecture 2: Non-isolated DC-DC converters (BUCK, BOOST and BUCK-BOOST) in Continuous Current Mode (CCM) their operating principles

Lecture 3: Non-isolated DC-DC converters in Discontinuous Current Mode (DCM) their operating principles

- Bridge based DC-AC inverter/rectifier

Lecture 4: Bridge converter, the circuit, working principle and applications

Lecture 5: Single phase DC-AC inverter and Sinusoidal Pulse Width Modulation (SPWM)

Lecture 6: Three phase DC-AC inverter/rectifier and AC line filter design

Lecture 7: Tutorial 1: DC-DC and DC-AC converters (two Tripos level questions)

- Diode based AC-DC rectifier

Lecture 8: Uncontrolled single AC-DC rectifier with ideal AC source, diode bridge circuit and principles, capacitor filtering techniques

Lecture 9: Uncontrolled three AC-DC rectifier with ideal AC source, diode bridge circuit and principles, capacitor filtering techniques

- Isolated DC-DC converter

Lecture 10: Isolated DC-DC converter: high frequency transformers, push-pull converter

Lecture 11: Flyback DC-DC converter: working principles and design requirements

Lecture 12: LLC Resonant converter: working principles and design requirements

Lecture 13: Tutorial 2: AC-DC diode based rectifier and isolated DC-DC converters (Flyback and LLC Resonant)

- Power electronic devices

Lecture 14: Power diodes and bipolar junction transistor

Lecture 15: The Insulated Gate Bipolar Transistor (IGBT): modes of operation. trade-offs.

Lecture 16: The power MOSFET: Concept, modes of operation. trade-offs.

## Examples papers

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

## Coursework

### DC-DC converter (upgraded new lab kit and facility from 2020)

Objectives:

- Be familiar with real power electronic and passive devices and their packages
- Use digital oscilloscope for power electronic system testing and data acquisition
- Use voltage and current probe of measuring switching voltage and current
- Observe and operate Pulse Width Modulation (by pulse generator) of controlling power electronic system
- Observe and operate passive components in power electronic systems and understand their functions

Pre-requisite

- Watch introductory video prior lab
- Read lab sheet prior lab

Full Technical Report:

- Optional tasks and questions are given for FTR

## Booklists

Please refer to the Booklist for Part IIA 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](#) [2].

## UK-SPEC

The [UK Standard for Professional Engineering Competence \(UK-SPEC\)](#) [3] 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'](#)

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[\(AHEP\) document](#) [4] which sets out the standard for degree accreditation.

The [Output Standards Matrices](#) [5] 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] <http://teaching.eng.cam.ac.uk/content/form-conduct-examinations>

[3] <http://www.engc.org.uk/ukspec.aspx>

[4] <http://www.engc.org.uk/standards-guidance/standards/accreditation-of-higher-education-programmes-ahep/>

[5] <http://teaching.eng.cam.ac.uk/content/output-standards-matrices>