Engineering Tripos Part IIB, 4B2: Power Microelectronics, 2021-22

Module Leader

Prof F Udrea [1]

Lecturer

Prof F Udrea

Timing and Structure

Michaelmas term. 14 lectures (includes one example class). Assessment: 100% exam. Note: First two lectures are ONLINE. check timetable in Moodle.

Prerequisites

3B3 & 3B5 useful

Aims

The aims of the course are to:

- provide an introduction to the world of modern power semiconductor devices, and their applications in the electronics Industry.
- cover material specific to power semiconductor devices not covered in other modules in semiconductors.

Objectives

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

- understand how the design of power semiconductor devices takes account of high voltage and currents
- explain the practical operating conditions pertaining to power semiconductor devices
- analyse power circuit segments
- know the features of the main types of power electronic devices
- understand the semiconductor technologies in power devices

Content

Introduction

Introduction to power electronics and power devices. Basics of power electronics, power devices and applications. P-N junction theory.

Power Diodes

High voltage pn junction theory. Breakdown theory. None punch-through (NPT) and punch-through (PT) high voltage junction. On-state - high level injection. Lifetime. Turn-off reverse recovery

Field Control

Curvature effects in high voltage junctions, Edge effects, Field plates, Terminations in power devices.

Power Bipolar Devices

Bipolar Juction transistor (BJT).

Thyristors

The thyristor (concept & technology). The GTO thyristor, Switching aids for transistors and thyristors.

Power MOS Devices

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

Power MOSFET Modelling

The power MOSFET modelling, technologies and advanced devices.

Insulted Gate Bipolar Transistors

The Insulted Gate Bipolar Transistor (IGBT): modes of operation. trade-offs.

IGBTs II

The IGBTs, modelling, technologies and advanced concepts.

Power Integrated Circuits (PICs)

Power Intergated Circuits (PICS) and High Voltage Integrated Circuits (HVICs): introduction, lateral devices for PICs and HVICs, concepts, modes of operation.

Wide bandgap materials and devices.

Figure of merit (FOM) for wide bandgap materials. Architectures, designs and challenges of Silicon Carbide (SiC) and Gasllium Nitride (GaN) devices.

Coursework

n/a

Booklists

Please refer to the Booklist for Part IIB 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

This syllabus contributes to the following areas of the UK-SPEC [3] 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.

IA2

Demonstrate creative and innovative ability in the synthesis of solutions and in formulating designs.

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.

US4

An awareness of developing technologies related to own specialisation.

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