ES4D4-15 Power Electronic Converters & Devices

22/23

Department
School of Engineering
Level
Undergraduate Level 4
Module leader
Jihong Wang
Credit value
15
Module duration
10 weeks
Assessment
30% coursework, 70% exam
Study location
University of Warwick main campus, Coventry

Description

Introductory description

ES4D4-15 Power Electronic Converters & Devices

Practically all electronic equipment, whether domestic or industrial, requires power conditioning to deliver the energy for it to operate correctly. This is using electronics for power processing, not information processing. The applications vary widely from power supplies for laptops and mobile phone chargers, through industrial motor drives, hybrid and electric vehicle drives, electric rail transport, to solar and wind energy systems and power transmission and distribution systems.

Module web page

Module aims

The module aims are:

- To introduce the concept of power electronics as power processing and control, and to present the range of applications of power electronics in today’s society.
- To introduce power semiconductor devices as basic switching elements used in power electronic converters, and describe the theory of their operation.

- To introduce power electronic converters, explain their operation principles and give examples of applications.
- To develop an understanding of the issues present in converter and device design, including the impact of physical layout and heat dissipation.

Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

- Introduction to power electronics, devices and applications.
- Semiconductor theory: revision and in depth discussion. Band theory, doping, p-n junctions. Avalanche breakdown and punchthrough. Carrier lifetime and the effect on resistance and switching speeds.
- Power semiconductor device physics: PiN and Schottky diodes, thyristors, bipolar transistors, MOSFETs, IGBTs.
- An introduction to wide bandgap semiconductors and devices. An insight into silicon carbide; specifically, its advantages and potential (high voltage, high frequency and high temperature devices) and its problems (cost, immaturity, processing issues).
- Power semiconductor device fabrication.
- An introduction to active on-going research topics in power semiconductor devices.
- Power converters: AC-DC converters, DC-DC converters, isolated converters, bridges and 3-phase inverters, resonant converters.
- Non-ideal cases, commutation and overlap, introduction of power quality and filters.
- Drives: DC motor control.
- Design, modelling and simulation of converters and devices.
- Applications: solar power, distributed generation, wind power, hybrid & electric vehicles.

Learning outcomes

By the end of the module, students should be able to:

- Acquire comprehensive knowledge of the design of power semiconductor devices.
- Apply the concepts of device physics in the context of device switching in a power converter.
- Analyse a simple power converter, including an AC-DC converter, a DC-DC converter and a DC-AC inverter.
- Analyse the power quality and harmonics. Design the basic filters to smooth the converter output and to improve the power quality.
- Explain the practical issues in converter design.
- Demonstrate a systematic knowledge in DC motor drives and control analysis.
- Demonstrate knowledge of new wide bandgap power devices.
- Understand the converter design method; design and test a boost DC-DC converter and its associated closed loop system control.

Indicative reading list

1. Power Electronics: a first course, Ned Mohan, ISBN : 978-1-118-07480-0, Wiley 2012.

2. Power Electronics, Ned Mohan; William P. Robbins; Tore M. Undeland, Wiley 2017
3. Fundamentals of silicon carbide technology, T. Kimoto and J.A. Cooper, ISBN 9781118313527, Wiley, 2014.
4. Advanced Power Electronics Converters: PWM Converters Processing AC Voltages, Euzeli Cipriano dos Santos Jr. and Edison Roberto Cabral da Silva, ISBN 978111888695, Wiley, 2015.
5. Elements of power electronics, Philip T. Krein, Oxford, 2016.
6. Fundamentals of power semiconductor devices, Baliga, Springer Science & Business Media, 2010
7. Introduction to modern power electronics, Andrzej Trzynadlowski, Wiley, 2016.

Research element

New development in power electronic device and converter design.
Using research project and research outcome as examples in the teaching to show how research drives the technology progress.

Subject specific skills

Power electronic device and their materials, formation, packaging, protection.
Power device selections and quantity analysis
Power electronic converter design and circuit analysis
Practical skills in device and converter modelling and simulation, analysis for parameter optimisation
Practical skills in converter parameter tuning
Converter dynamic modelling and transition analysis

Transferable skills

Practical skills in electronic equipment usage
Lab report writing and results analysis and presentation.
Computer simulation using PSPICE software

Study

Study time

Type	Required
Lectures	30 sessions of 1 hour (20%)
Practical classes	12 sessions of 1 hour (8%)
Other activity	6 hours (4%)
Private study	102 hours (68%)
Total	150 hours

Private study description

Guided Independent Learning 102 hours

Other activity description

4 X 1 hour Example Classes
2 X 1 hour Revision Classes

Costs

No further costs have been identified for this module.

Assessment

You must pass all assessment components to pass the module.

Students can register for this module without taking any assessment.

Assessment group DD

	Weighting	Study time
Assignment	30%	

This is to design a DC-DC boost converter with a guide of the design specifications. The designed converter will be analysed via simulation using a PSPICE software and the analysis includes choosing the suitable device and components and examining the converter performance. The converter will be tested via practical laboratory experimental work. In the laboratory test, a closed-loop control will be introduced and tested to understand how the converter output voltage is maintained via feedback control.
15 Pages.

In-person Examination	70%	

Standard written examination.

- Answerbook Pink (12 page)
- Engineering Data Book 8th Edition
- Students may use a calculator
- Graph paper

Feedback on assessment

Solutions to questions in problem sheets and discussion of the solutions during example classes.

Marked assignments.
Cohort level feedback on examinations

Past exam papers for ES4D4

Availability

Pre-requisites

To take this module, you must have passed:

- All of
  - ES191-15 Electrical and Electronic Circuits
  - ES2C0-15 Analogue Electronic Design

Post-requisite modules

If you pass this module, you can take:

- ES4E8-15 Advanced Power Electronic Converters and Devices

Courses

This module is Core for:

- Year 1 of RESA-H6P9 Postgraduate Research Wide Bandgap Power Electronics

This module is Core optional for:

- Year 2 of RESA-H6P9 Postgraduate Research Wide Bandgap Power Electronics
- Year 1 of TESA-H643 Postgraduate Taught Electrical Power Engineering
- Year 1 of TESA-H642 Postgraduate Taught Energy and Power Engineering

This module is Optional for:

- Year 4 of UESA-H116 MEng Engineering with Exchange Year
- Year 5 of UESA-H115 MEng Engineering with Intercalated Year
- Year 2 of TESA-H1A0 Postgraduate Taught Sustainable Energy Technologies

This module is Option list A for:

- Year 4 of UESA-H114 MEng Engineering
- Year 4 of UESA-H311 MEng Mechanical Engineering

This module is Option list B for:

- Year 4 of UESA-HH31 MEng Systems Engineering

- Year 4 of UESA-HH33 MEng Systems Engineering with Exchange Year
- Year 5 of UESA-HH32 MEng Systems Engineering with Intercalated Year
- Year 4 of UCSA-G408 Undergraduate Computer Systems Engineering
- Year 5 of UCSA-G409 Undergraduate Computer Systems Engineering (with Intercalated Year)