# ES4D4-15 Power Electronic Converters & Devices

## 21/22

**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

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## Description

## Introductory description

ES4D4-15 Power Electronic Converters & Devices

Module web page

## Module aims

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.

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 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 fabrication techniques

## 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.
- Design and analysis of a 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.
- Consolidate knowledge on the practical issues in converter design.
- Demonstrate a systematic knowledge in DC motor drives and control analysis.
- Evaluate the applications of power electronics and the development of new devices.
- Design and test a boost DC-DC converter and the associated control.

## Indicative reading list

1. Power Electronics: a first course, Ned Mohan, ISBN : 978-1-118-07480-0, Wiley 2012.
2. Fundamentals of silicon carbide technology, T. Kimoto and J.A. Cooper, ISBN 9781118313527, Wiley, 2014.
3. S.M. Sze and K.K. Ng, Physics of semiconductor devices, ISBN 9780471143239 Wiley, 2007.
4. Advanced electric drives : analysis, control, and odelling using MATLAB/Simulink, Ned Mohan, ISBN 978111891113, Wiley , 2014.
5. Electric machines and drives : a first course, Ned Mohan, ISBN 9781118074817, Wiley, 2012.
6. Advanced Power Electronics Converters: PWM Converters Processing AC Voltages, Euzeli Cipriano dos Santos Jr. and Edison Roberto Cabral da Silva, ISBN 978111888695, Wiley, 2015.
7. Electromagnetic compatibility in power electronics, Laszlo Tihanyi, Butterworth-Heinemann, ISBN 9781118863183, Wiley, 2014.

## Research element

The recent development and research topic in the area will be introduced to the students
Research project and outcome are used as examples in delivering the lectures.

## Subject specific skills

TBC

## Transferable skills

Computer simulation and CAD
Lab report writing and experimental data analysis
Electronic equipment operation.

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## 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.

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## Assessment

You must pass all assessment components to pass the module.

Students can register for this module without taking any assessment.

### Assessment group DC

| | Weighting | Study time | Eligible for self-certification |
|---|---|---|---|
| **Assessment component** | | | |
| (Practical/simulation) lab based assignments 1 (4 pages each) 1000 words | 15% | | No |
| This is to use a professional CAD software to perform analysis of device characteristics and converter performance. | | | |
| **Reassessment component is the same** | | | |
| **Assessment component** | | | |
| (Practical/simulation) lab based assignments 2 (4 pages each) 1000 words | 15% | | No |
| This assessment requires the student to design a boost DC-DC converter key component parameters and test the design in the lab. It includes open-loop and closed loop control of the converter. | | | |
| **Reassessment component is the same** | | | |

| | Weighting | Study time | Eligible for self-certification |
|---|---|---|---|
| **Assessment component** | | | |
| Online Examination<br>QMP online examination (to be 2 x 1hr with a gap in between)<br>~Platforms - AEP,QMP | 70% | | No |

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

**Reassessment component is the same**

### 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

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## 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 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 UCSA-G408 Undergraduate Computer Systems Engineering