ES4E8-15 Advanced Power Electronic Converters and Devices

20/21

Department
School of Engineering
Level
Undergraduate Level 4
Module leader
Oleh Kiselychnyk
Credit value
15
Module duration
10 weeks
Assessment
40% coursework, 60% exam
Study location
University of Warwick main campus, Coventry

Description

Introductory description

ES4E8-15 Advanced Power Electronic Converters and 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. With the foundation of studying the module ES3E0 Power Electronics, ES4E8 is to give students a wide range, in-depth and advanced knowledge of Power Electronics and Devices.

The module aims are:

- To introduce the advanced power electronics as power processing and control, and to present the power electronics converters used for switch-mode power supplies, connection

of renewable energy to the power grid and electrification of transportation.
- To introduce advanced power semiconductor device design concepts for industry-ready power electronic converter components, and describe the theory of their operation.
- Advanced packaging and reliability considerations for power electronic converters, taking into account thermal and switching budgets.
- To introduce emerging and future power semiconductor devices utilising new materials such as silicon carbide and gallium nitride.
- To introduce power electronic converters/inverters and control for various applications and give design examples.

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.

- Current source converters: topology, design and analysis.
- Voltage source converters: topology, design and analysis.
- Matrix converters: topology, design and analysis.
- Multi-level converters: Neutral-point-clamped configuration, Flying capacitor configuration, cascade configuration and modular multilevel converters.
- Control strategy for power electronic converters.
- Revision of semiconductor theory presented in ES3E0.
- Advanced power semiconductor device design concepts: silicon-on-insulator (SOI), reduced surface electric field effect (RESURF), super-junction technology, lifetime control, junction termination, high voltage (smart) power ICs.
- Wide bandgap semiconductors and devices. An insight into silicon carbide and gallium nitride, its advantages and potential (high voltage, high frequency and high temperature devices) and its problems (cost, immaturity, processing issues).
- Packaging and reliability of power semiconductor devices.

Learning outcomes

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

- Understand the operation and conceptual design principles of advanced power converters with PWM control.
- Systematically analyse and design multilevel power electronic converters.
- Design the control of advanced power converters for different applications.
- Conduct complex packaging and reliability analysis of power semiconductor devices.
- Design a power semiconductor device.
- Analyse systematically new materials for power semiconductor devices; silicon carbide and gallium nitride.
- Apply advanced concepts through the use of device physics in the context of device design

Indicative reading list

1. B. J. Baliga, Fundamentals of Power Semiconductor Devices, ISBN 0387473130 Springer,

2008.
2. Fundamentals of silicon carbide technology, T. Kimoto and J.A. Cooper, ISBN 9781118313527, Wiley, 2014.
3. Advanced Power Electronics Converters: PWM Converters Processing AC Voltages, Euzeli Cipriano dos Santos Jr. and Edison Roberto Cabral da Silva, ISBN 978111888695, Wiley, 2015.
4. Power Electronics and Motor Drives, edited by Bogdan M. Wilamowski, J. David Irwin, Print ISBN: 978-1-4398-0285-4, eBook ISBN: 978-1-4398-0286-1, CRC Press 2011.
5. Power Electronic Converters Modeling and Control with Case Studies, Seddik Bacha, Iulian Munteanu, Antoneta Iuliana Bratcu, ISBN: 978-1-4471-5477-8 (Print) 978-1-4471-5478-5 (Online), Springer-Verlag London 2014.

Subject specific skills

1. Ability to conceive, make and realise a component, product, system or process
2. Ability to be pragmatic, taking a systematic approach and the logical and practical steps necessary for, often complex, concepts to become reality

Transferable skills

1. Numeracy: apply mathematical and computational methods to communicate parameters, model and optimize solutions
2. Apply problem solving skills, information retrieval, and the effective use of general IT facilities
3. Communicate (written and oral; to technical and non-technical audiences) and work with others

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Study

Study time

Type	Required
Lectures	30 sessions of 1 hour (20%)
Practical classes	2 sessions of 3 hours (4%)
Other activity	4 hours (3%)
Private study	110 hours (73%)
Total	150 hours

Private study description

Guided independent learning 110 hours.

Other activity description

2 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 D5

	Weighting	Study time
Laboratory Reports 1 A 1,500-word laboratory report.	20%	
Laboratory Reports 2 A 1,500-word laboratory report.	20%	
Online Examination QMP ~Platforms - QMP	60%	

- Students may use a calculator
- Engineering Data Book 8th Edition
- Graph paper

Feedback on assessment

Solutions to questions in problem sheets and discussion of the solutions during example classes.
Marked laboratory reports.
Cohort level feedback on examinations

Past exam papers for ES4E8

Availability

Pre-requisites

To take this module, you must have passed:

- All of
  - ES3E0-15 Power Electronics
  - ES4D4-15 Power Electronic Converters & Devices

Courses

This module is Core for:

- Year 4 of UESA-H63X MEng Electronic Engineering
- Year 5 of UESA-H636 MEng Electronic Engineering with Intercalated Year
- Year 1 of TESA-H643 Postgraduate Taught Electrical Power Engineering
- Year 1 of TESA-H642 Postgraduate Taught Energy and Power Engineering
- Year 4 of UESA-H606 Undergraduate Electrical and Electronic Engineering MEng

This module is Core optional for:

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

This module is Option list A for:

- Year 4 of UESA-H114 MEng Engineering