ES4E8

UNIVERSITY OF WARWICK

Proposal Form for New or Revised Modules (MA1 - version 7 - April 2014)

Approval information	
Approval Type	☐ New module ☒ Revised module ☐ Discontinue module
Date of Introduction/Change	October 2018
If new, does this module replace another? If so, enter module code and title:	
If revised/discontinued, please outline the rationale for the changes:	Revised to reflect small changes in the syllabus and improve description of learning outcomes (ticked IET learning outcomes are still satisfied). Assessed work increased to 30%.
Confirmation that affected departments have been consulted:	Changes have been made in consultation between the School of Engineering and WMG.

Module Summary	
1. Module Code (if known)	ES4E8
2. Module Title	Advanced Power Electronic Converters and Devices
3a. Lead department:	Engineering
3b. Teaching Split (if known):	100% Engineering
4. Name of module leader	Dr Oleh Kiselychnyk
5. Level	UG: ☐ Level 4 (Certificate) ☐ Level 5 (Intermediate) ☐ Level 6 (Honours) PG: ☒ Level 7 (Masters) ☐ Level 8 (Doctoral) See Guidance Notes for relationship to years of study
6. Credit value(s) (CATS)	15CATS
7. Principal 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,

Module Summary	
	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.
8. Principal Learning Outcomes	By the end of the module the student 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. • Apply advanced concepts through the use of device physics in the context of device design (forward, reverse characteristics and switching) for use within a power converter.

Module Summary	
	• Design a power semiconductor device. • Conduct complex packaging and reliability analysis of power semiconductor devices. • Analyse systematically new materials for power semiconductor devices; silicon carbide and gallium nitride.
9. Timetabled Teaching Activities (summary)	Lectures 30 × 1 hour 2 X 1 hour Example Classes and 2 x 1 hour Revision Classes 6 hours of Practical Exercises/Labs (2x3 hours), Total: 40 hours
10. Departmental Web-link	www2.warwick.ac.uk/fac/sci/eng/eso/modules/year4/es4e8
11. Other essential notes	Advice and feedback hours for answering questions on the lecture material (theory and examples) and past examination questions.
12. Assessment methods (summary)	70% examined via a 3 hour examination paper and 30% assessed via two laboratory reports/course work 1500 words (15% each).

For use by Strategic Planning and Analytics Office only - Do not fill in this section

Level	JACS3 Code	Teaching Split
		If not provided in 3b above

External Credit Level		Scheme	

Module Context
13. Please list all departments involved in the teaching of this module. If taught by more than one department, please indicate percentage split.
School of Engineering
14. Availability of module

Degree Code	Title	Study Year	C/OC/ A/B/C	Credits
H635	MEng Electronic Engineering and variants	4	C	15
H64Z	MEng Electronic Engineering with Exchange Year	4	C	
H636	MEng Electronic Engineering with Intercalated Year	5	C	
H637	MEng Electronic Engineering with Year in Research	5	C	
H642	MSc Energy and Power Engineering	1	C	
H107	MEng Engineering (and variants)	4	O	
New	MEng Engineering with Exchange Year	4	O	
H109	MEng Engineering with Intercalated Year	5	O	
H110	MEng Engineering with Year in Research	5	O	

15. Minimum number of registered students required for module to run
1 – core module
16. Pre- and Post-Requisite Modules
Pre-requisite ES3E0 Power Electronics or ES4D4 Power Electronics Converters and Devices

Module Content and Teaching	
17. Teaching and Learning Activities *(totals for module – please see guidance)*	
Module duration (weeks)	10
Lectures	30 x 1 hour
Seminars	
Tutorials	
Project Supervision	
Demonstration	
Practical Class/Workshops	6 hours (2x3 hours)
Supervised time in	

Module Content and Teaching	
studio/workshop	
Fieldwork	
External visits	
Work based learning	
Placement	
Year abroad	
Other activity *(please describe): e.g. distance-learning, intensive weekend teaching etc.*	2 X 1 hour Example Classes 2 X 1 hour Revision Classes Guided independent learning 110 hours

18. Assessment Method (Standard)		
Type of assessment	**Length**	**% weighting**
Written Examinations	Hours 3	70
Practical Examinations		
Assessed essays/coursework	2 Laboratory reports 1500 words (15% each)	30
18a. Final chronological assessment *(please see guidance)*	Examination	

19. Methods for providing 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

20. Outline Syllabus

- 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.
21. Illustrative Bibliography
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.
22. Learning outcomes *Successful completion of the module leads to the learning outcomes. The learning outcomes identify the knowledge, skills and attributes developed by the module.* *Learning Outcomes should be presented in the format "By the end of the module students should be able to..." using the table at the end of the module approval form:*

Resources
23. List any additional requirements and indicate the outcome of any discussions about these.
None

Approval	
24. Module leader's signature	Dr Oleh Kiselychnyk
25. Date of approval	25 April 2018
26. Name of Approving Committee (include minute reference if applicable)	School of Engineering and WMG Course and Module Approval Committee (CMAC), Minute 258-17/18.
27. Chair of Committee's signature	Professor Gillian Cooke
28. Head of Department(s) signature	Professor David Towers

Examination Information		
A1. Name of examiner (if different from module leader)		
A2. Indicate all available methods of assessment in the table below		
% Examined	**% Assessed by other methods**	**Length of examination paper**
70	**15 Laboratory Assignment 1 1500 words** **15 Laboratory Assignment 2 1500 words**	**3 hours**
A3. Will this module be examined together with any other module (sectioned paper)? If so, please give details below.		
A4. How many papers will the module be examined by?	1 paper	
A5. When would you wish the exam take place (e.g. Jan, April, Summer)?	**Summer**	
A6. Is reading time required?	☐ Yes	☒ No
A7. Please specify any special exam timetable arrangements.		
A8. Stationery requirements		
No. of Answer books?	**2**	
Graph paper?	**Yes**	
Calculator?	**Yes**	
Any other special stationery requirements (e.g. Data books, tables etc)?	**Engineering Data book**	
A9. Type of examination paper		
Seen?	☐ Yes	☒ No
Open Book?	☐ Yes	☒ No
Restricted?	☐ Yes	☒ No
If restricted, please provide		

Approval	
a list of permitted texts:	

LEARNING OUTCOMES		
(By the end of the module the student should be able to....)	**Which teaching and learning methods enable students to achieve this learning outcome? (reference activities in section 15)**	**Which summative assessment method(s) will measure the achievement of this learning outcome? (reference activities in section 16)**
Understand the operation and conceptual design principles of advanced power converters with PWM control.	Lectures, design examples, laboratory	Examination and laboratory report
Systematically analyse and design multilevel power electronic converters.	Lectures, design examples	Examination
Design the control of advanced power converters for different applications.	Lectures, design examples	Examination
Apply advanced concepts through the use of device physics in the context of device design (forward, reverse characteristics and switching) for use within a power converter.	Lectures, design examples, laboratory	Examination and laboratory report
Design a power semiconductor device.	Lectures, design examples	Examination
Conduct complex packaging and reliability analysis of power semiconductor devices.	Lectures, design examples	Examination
Analyse systematically new materials for power semiconductor devices; silicon carbide and gallium nitride.	Lectures, design examples	Examination