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 2017
If new, does this module replace another? If so, enter module code and title:	
If revised/discontinued, please outline the rationale for the changes:	
Confirmation that affected departments have been consulted:	Changes were made in consultations between the School of Engineering and WMG.

Module Summary	
1. Module Code (if known)	ES3E0
2. Module Title	Power Electronics
3a. Lead department:	School of Engineering
3b. Teaching Split (if known):	100% Engineering
4. Name of module leader	Jihong Wang
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)	15

Module Summary	
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, 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 heat dissipation.
8. Principal Learning Outcomes	By the end of the module the student should be able to • Describe the operation of power semiconductor devices. • Apply the concepts of device physics in the context of device switching in a power converter. • Design 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. • Appreciate the applications of power electronics and the development of new devices.
9. Timetabled Teaching Activities (summary)	Lectures 30 × 1 hour 4 X 1 hour Example Classes 2 X 1 hour Revision Classes 12 hours Labs **Total 48 hours**

Module Summary	
10. Departmental Web-link	www2.warwick.ac.uk/fac/sci/eng/eso/modules/year3/es3e0
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)	80% examined via a 3 hour exams paper 20% assessed via 2 lab based assignments (10% 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
H634	BEng Electronic Engineering	3	C	
H635	MEng Electronic Engineering (and variants)	3	C	
H636	MEng Electronic Engineering with Intercalated Year	3	C	
H637	MEng Electronic Engineering with Year in Research	3	C	
H106	BEng Engineering	3	O	
H107	MEng Engineering (and variants)	3	O	
H109	MEng Engineering with Intercalated Year	3	O	
H110	MEng Engineering with Year in Research	3	O	

15. Minimum number of registered students required for module to run
1 – core module
16. Pre- and Post-Requisite Modules
ES185 Electrical and Electronic Engineering, ES2B1 Energy Conversion and Power Systems, ES2B3 Engineering Materials

Module Content and Teaching Energy Conversion and Power Systems	
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	12 hours
Supervised time in	

Module Content and Teaching Energy Conversion and Power Systems		
studio/workshop		
Fieldwork		
External visits		
Work based learning		
Placement		
Year abroad		
Other activity *(please describe): e.g. distance-learning, intensive weekend teaching etc.*	4 X 1 hour Example Classes 2 X 1 hour Revision Classes Guided independent learning 102 hours	
18. Assessment Method (Standard)		
Type of assessment	**Length**	**% weighting**
Written Examinations	Hours 3	80
Practical Examinations		
Assessed essays/coursework	(Practical/simulation) lab based assignments	20 (2 x 10%)
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 assignments.
Cohort level feedback on examinations.

20. Outline Syllabus

- 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.
- 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 and simulation of converters and devices.
- Applications: solar power, distributed generation, wind power, hybrid & electric vehicles.

21. Illustrative Bibliography

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 modeling 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.

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:

Please see 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	Professor Jihong Wang
25. Date of approval	Teaching Policy Committee Chair's Action 31 March 2017
26. Name of Approving Committee (include minute reference if applicable)	School of Engineering and WMG Teaching Policy Committee
27. Chair of Committee's signature	Professor Gillian Cooke
28. Head of Department(s) signature	Professor Nigel Stocks

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**
80	10 Assignment 1 10 Assignment 2	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.		
Schedule examination with the examination for ES4D4.		
A8. Stationery requirements		
No. of Answer books?	**2**	
Graph paper?	**Yes**	
Calculator?	**Yes**	
Any other special stationery requirements (e.g. Data books, tables etc)?	**Data book**	
A9. Type of examination paper		
Seen?	☐ Yes	☒ No
Open Book?	☐ Yes	☒ No
Restricted?	☐ Yes	☒ No
If restricted, please provide 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)**
Describe the operation of power semiconductor devices; apply the concepts of device physics in the context of device switching in a power converter.	Lectures, design examples and simulation	Examination and assignments
Design a simple power converter, including a AC-DC converter, DC-DC converter and a DC-AC inverter.	Lectures, design examples and simulation	Examination and assignments
Analyse the power quality and harmonics. Design the basic filters to smooth the converter output and to improve the power quality.	Lectures, design examples and simulation	Examination
Explain the practical issues in converter design.	Lectures, design examples and simulation	Examination and assignments
Appreciate the applications of power electronics and the development of new devices.	Lectures, design examples and simulation	Examination