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	01/10/2017
If new, does this module replace another? If so, enter module code and title:	
If revised/discontinued, please outline the rationale for the changes:	Revised by updating content and adding 2 laboratory sessions, to improve student experience.
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)	ES97A
2. Module Title	Operation and Control of Power Systems
3a. Lead department:	School of Engineering
3b. Teaching Split (if known):	100% School of Engineering
4. Name of module leader	Professor Li Ran
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	This module aims to present the current (advanced) technologies and trends in development that will shape future electrical power systems. The students will gain a comprehensive knowledge and understanding of the construction, operation and control principles of power systems. They will learn advanced analytical skills for examining different modes of operation in complex systems. The content includes the following main elements: - Generation, Transmission and Distribution of Electrical Power - Balanced and Unbalanced 3-Phase Systems - Load Flow Analyses - Fault and Stability Analyses of Power Systems - Power System Protection Concepts and Techniques - Operational Security Control - Benefits and Limitations of Wide Area Measurement (WAM) - Effects and Management of Distributed Generation - Flexible AC Transmission Systems (FACTS) and High Voltage DC (HVDC) Transmission Technologies - Power Quality Monitoring and Management - Renewable Power Penetration and Grid Code Requirements - The Role of Energy Storage and the Development of Relevant Technologies - Smart Grids
8. Principal Learning Outcomes	By the end of the module the student should be able to: • Demonstrate a systematic knowledge of the complex operation and control of modern power systems, of the constitution of current and future generation power systems, of load flow, of stability and faults in current generation and of future power systems, including frequency and voltage control. • Demonstrate an advanced understanding of power quality monitoring and control • Evaluate the effectiveness of using wide area measurement systems • Critically assess the effects of future renewable penetration and distributed generation, and the ability to apply advanced control techniques
9. Timetabled Teaching Activities (summary)	25 x 1 hours of Lectures 2 x 1 hour of examples classes 2 x 1 hour revision classes 2 x 2 hours of supervised laboratory sessions 1 x 2 hours industrial visit 1 x 1 hour industrial lecture

Module Summary	
	Total 36 hours
10. Departmental Web-link	http://www2.warwick.ac.uk/fac/sci/eng/eso/modules/year4/es97a/
11. Other essential notes	Advice and feedback hours are available for answering questions on the lecture material (theory and examples) and past examination questions.
12. Assessment methods (summary)	90% Examination (3 hours) 2 x 5% Laboratory Quizzes (5 pages)

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
H650	MSc Energy and Power Engineering	1	C	15
H1A0	MSc Sustainable Energy Technologies	1	O	15

15. Minimum number of registered students required for module to run

1 (Core)

16. Pre- and Post-Requisite Modules

Electric Circuit Theory

Module Content and Teaching

17. Teaching and Learning Activities *(totals for module – please see guidance)*

Module duration (weeks)	**12 + 2 (in summer term)**
Lectures	**26 x 1 hour**
Seminars	
Tutorials	**Example Classes 2 x 1 hour (in summer term)**
Project Supervision	
Demonstration	
Practical Class/Workshops	**Laboratory 2 x 2 hours**
Supervised time in studio/workshop	
Fieldwork	
External visits	1 x 2 hours
Work based learning	
Placement	
Year abroad	
Other activity *(please describe): e.g. distance-learning, intensive weekend teaching etc.*	**2 x 1 hour Revision Classes** **114 hours Guided Independent Learning**

18. Assessment Method (Standard)

Type of assessment	Length	% weighting
Written Examinations	3 Hours	**90**

Module Content and Teaching		
Practical Examinations		
Assessed essays/coursework	Laboratory Quiz 1 Laboratory Quiz 2	**5** **5**
18a. Final chronological assessment *(please see guidance*)	**Examination**	

19. Methods for providing feedback on assessment.

The students will obtain feedback through contact with lecturer during office hours. Exercises will be given after every lecture and solutions will be provided in the next week. The students will also obtain written feedback on the laboratory quizzes. There will also be cohort level feedback on examinations.

20. Outline Syllabus

- Fundamentals of 3-Phase AC Power Systems
- Planning and Expansion of Power Systems
- Power Flow Calculation and Security Analysis of Network Operation
- Fault Calculation and Power System Protection
- Power System Stability Calculation and Control
- Wind Turbine/Farm Characteristics
- Challenges of Wind Power Integration in Power Systems
- Shunt Reactive Power Compensation Technologies
- Controllable Series Compensators in Transmission Networks
- HVDC Transmission – LCC Technologies
- VSC (voltage source converters) – HVDC
- Control of Grid-Connected VSC
- Flexible AC Transmission Systems (FACTS)
- Integration of Large Scale PV Generation
- Marine Renewable Generation
- Control of Power System Frequency and Voltage
- OLTC – On Load Tap Changer of Transformers
- Handling of Power Quality Issues in Power Systems
- Fault Level Management
- Combined Heat and Power
- Microgrids and Future Smart Grids

21. Illustrative Bibliography

1. Seifi H. and Sepasian M.S., Electric Power System Planning - Issues, Algorithms and Solutions, Springer 2011
2. Wildi T., Electricl Machines, Drives, and Power Systems, Pearson Prentice Hall, 2014
3. Weedy B.M., Cory B.J., Jenkins N., Ekanayake J.B. and Strbac G. Electric Power Systems (5th Ed), John Wiley & Sons, 2012
4. Kundur P., Power System Stability and Control, McGraw-Hill, 1994

5. Horowitz S.H. and Phadke A.G., Power System Relaying (4th Ed), John Wiley & Sons, 2014
6. Freris L. and Infield D., Renewable Energy in Power Systems, John Wiley & Sons, 2008 (to be updated in 2018)

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.

Approval

24. Module leader's signature	Professor Li Ran
25. Date of approval	Teaching Policy Committee Chair's Action 4 April 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**
90%	**5% Laboratory Quiz 1** **5% Laboratory Quiz 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	☐ 2 papers
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?	**1**	
Graph paper?	**Yes**	
Calculator?	**Yes (student)**	
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 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)**
Demonstrate a systematic knowledge of the complex operation and control of modern power systems, of the constitution of current and future generation power systems, of load flow, of stability and faults in current generation and of future power systems, including frequency and voltage control.	Lectures, example classes	Examination
Demonstrate an advanced understanding of power quality monitoring and control.	Lectures, example classes	Examination and laboratory
Evaluate the effectiveness of using wide area measurement systems.	Lectures, example classes	Examination
Critically assess the effects of future renewable penetration and distributed generation, and the ability to apply advanced control techniques.	Lectures, example classes	Examination and laboratory