The University Of Sheffield.

Electronic & Electrical Engineering.

EEE307 POWER ELECTRONICS

Credits: 10

Course Description including Aims

1. To introduce and develop an understanding of power electronic devices and circuits.
2. To develop circuit analysis techniques, circuit understanding and design capabilities for use in ac and dc power converters.

Outline Syllabus

Power Diodes : rectification, form factors, parallel and series connection, stored charge problems. **Switching Devices :** static and dynamic characteristics, loss mechanisms and drive requirements of Bipolar, Mosfet and IGBT devices, parallel operation and comparison with Thyristor and GTO devices and requirements. **Converters :** AC to DC, DC to AC and DC to DC conversion systems, basic principles and main operational considerations. Switched mode power supplies, alternative circuit configurations and outline designs. Resonant switching techniques. Snubber circuits. Noise and interference from switching circuits. Heatsinking. Control strategies.

Time Allocation

24 lectures plus 12 hours of additional support material.

Recommended Previous Courses

Students may find it useful to have done the following modules:-
Signals and Systems EEE201
Electronic Devices in Circuits EEE204.
Analogue and Switching Circuits EEE340.
Feedback Systems Design EEE342

Assessment

2 Hour Examination, answer three questions from four.

Recommended Books

Lander, C.W.	*Power Electronics*	McGraw-Hill
Mohan N	*Power Electronics - Converters Applications & Design*	Wiley
Williams B.W.	*Power Electronics - Devices Drivers & Applications*	Macmillan
Kassakian, J.G	*Principles of Power Electronics*	Addison-Wesley

Objectives

By the end of the module successful students will be able to

1. Understand the terminal characteristics of, and be confident in using, power switching devices.
2. Design simple switched mode power supplies (isolated and non-isolated).
3. Produce a small signal transfer function for a simple switched mode power supply in order to stabilize its operation.
4. Design inverter bridges.

UK-SPEC/IET Learning Outcomes

Outcome Code	Supporting Statement
SM1p	The course teaches basic power electronics principles, which enables the students to understand the principles and methodology necessary to underpin their education in electrical and power electronic engineering, to enable appreciation of its scientific and engineering context, and to support their understanding of historical, current, and future developments and technologies. The ability to exploit these ideas is tested in the exam.
SM2p	The course includes mathematical notation consistent with the subject, and familiarises the students with the language necessary to progress in this field. Examination questions will be posed with the relevant standard notation, and answers will be expected in this format.
SM3p	The use of real-world problems in tutorials within the course allows the students opportunities to apply the knowledge to problems in the subject area, supporting their study in the area of power electronics and switched mode power supplies. The ability to exploit these ideas is tested in the exam.
SM1m	The areas considered by the course also include in-depth studies of circuit topologies particular to the power electronics discipline, and are examinable.
SM2m	State-space analysis of converters, covered in the course, gives a good example of where mathematical models of systems are derived, and then the limitations of the models are discussed. Similar treatment of systems would be expected in the exam.
SM3m	The use of real-world problems in tutorials within the course allows the students opportunities to apply the knowledge to problems in the subject area, supporting their study in the area of power electronics and switched mode power supplies. Similar questions may be posed in the exam.
SM4m	Inclusion of modern switching devices (SiC for example) and resonant converters for miniaturisation of power converters allows the students to develop an insight into future trends and developments in the field. Examination questions may require appreciation of the suitability of these technologies for a given specification.
EA1p	The course discusses basic engineering principles behind power electronic circuits and devices and applies them to example systems. The ability to exploit these ideas is tested in the exam.
EA2p	Through the course, the students gain the ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modelling techniques, with examples being given where

	appropriate. Treatment of similar systems and components may be tested for in the exam.
EA3p	Indication is given in the course as to how the mathematical models of systems can be used in MATLAB, for example, to determine system characteristics.
EA4p	The course promotes the use of systems based examples to help the students grasp the systems approach to the analysis of problems, for example the study of a switched mode power supply to see the interaction of the device ratings with the overall system performance. Derivation and calculation of such design equations for such systems would be tested for in the exam.
EA1m	The course discusses basic engineering principles behind power electronic circuits and devices and applies them to example systems, which may have safety critical considerations to be addressed. The ability to exploit these ideas is tested in the exam.
EA2m	Through the course, the students gain the ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modelling techniques, with examples being given where appropriate. Treatment of similar systems and components may be tested for in the exam.
EA3m	Indication is given in the course as to how the mathematical models of systems can be used in MATLAB, for example, to determine system characteristics.
EA4m	The course promotes the use of systems based examples to help the students grasp the systems approach to the analysis of problems, for example the study of a switched mode power supply to see the interaction of the device ratings with the overall system performance. Derivation and calculation of such design equations for such systems would be tested for in the exam.
EA5m	Fundamental knowledge of switching circuits is used to explore the emerging converter systems, leading the students to apply fundamental principles to explore emerging power converter technologies. Comparison of emerging technologies with regards to their fundamental operating characteristics would be examinable.
EA6m	Manufacturer's datasheets for components are often shown to evaluate the required safe-operating-areas for devices and their use in systems. Extracting such data would be tested for in the exam.
D1p	The examples used in the course show how systems can be designed from the user standpoint, with maximum and minimum allowable criteria being shown to influence the design of systems. Resonant switching action is described in order to develop more efficient, smaller, more aesthetically pleasing systems. Evaluation of the most optimum system for a given climate/topography/economy would be expected in an exam.
D3p	The effect of parameter tolerances and voltage swing is demonstrated. Best-guess initial approach to develop the necessary power electronics required for power transfer is described and developed to optimise efficiency. Input-output characteristics would be given in an exam and the necessary constraints/design decisions to be imposed would be expected. The ability to exploit these ideas is tested in the exam.
D1m	The development of power electronics in the context of efficiency, cost, geography and socio-economic impact is considered to enable future optimised grid-connected "smart" solutions. The need for societal appreciation of energy

	usage from mobile phones to EVs to smart cities is discussed during the lectures. Evaluation of the most optimum system for a given climate/topography/economy would be expected in an exam.
D3m	The effect of parameter tolerances and input-output voltage swing is discussed. Best-guess initial approach to develop the necessary power electronics required for power transfer is described and developed to optimise efficiency. Input-output characteristics would be given in an exam and the necessary constraints/design decisions to be imposed would be expected.
EP1p	The examples in the course show how the technology can be applied to various problems and in a number of situations to solve problems. This is re-enforced by the tutorial questions handed out in the lectures. Similar real-world systems may be examinable in the exam.
EP2p	The course imparts to the students the basic knowledge and characteristics of materials, for example switching devices, and equipment (power supplies) and leads them to an understanding of how the characteristics influence the system design. The ability to exploit these ideas is tested in the exam.
EP4p	Whilst the course is self-contained, every diagram/data table is referenced to its original author/text so that students may use manufacturer's handbooks for various devices and understand timing graphs and parameter tables for safe operation. Relevant electronic information sources are detailed for a broader appreciation of the many devices that cannot be discussed in the time available. The ability to extract relevant system data from a manufacturer's specification is tested for in the exam.
EP6p	Fundamental grid code requirements and industry standard practices are introduced. Health and safety constraints are discussed where relevant and tested for in the exam.
EP7p	Quality issues during manufacture of power electronic systems are discussed and contrasted for different devices/technologies. Discussion of developing trends arising from historical safety-critical quality issues identifies possible future technologies for development. Appreciation of the need for safe, repeatable use technology is tested for in the exam for given use scenarios.
EP8p	The effect of measurement error, parameter tolerances and input-output voltage swing is discussed. Best-guess initial approach to develop the necessary power electronics required for power transfer is described and developed to optimise efficiency. Input-output characteristics would be given in an exam and the necessary constraints/design decisions to be imposed would be expected.
EP1m	The examples in the course show how the technology can be applied to various problems and in a number of situations to solve problems. This is re-enforced by the tutorial questions handed out in the lectures. The ability to exploit these ideas is tested in the exam.
EP2m	The course imparts to the students the basic knowledge and characteristics of materials, for example switching devices, and equipment (power supplies) and leads them to an understanding of how the characteristics influence the system design. The ability to exploit these ideas is tested in the exam.
EP4m	Whilst the course is self-contained, every diagram/data table is referenced to its original author/text so that students may use manufacturer's handbooks for various devices and understand timing graphs and parameter tables for safe

	operation. Relevant electronic information sources are detailed for a broader appreciation of the many devices that cannot be discussed in the time available. The ability to extract relevant system data from a manufacturer's specification is tested for in the exam.
EP6m	Fundamental grid code requirements and industry standard practices are introduced. Health and safety constraints are discussed where relevant and tested for in the exam.
EP7m	Quality issues during manufacture of power electronic systems are discussed and contrasted for different devices/technologies. Discussion of developing trends arising from historical safety-critical quality issues identifies possible future technologies for development. Appreciation of the need for safe, repeatable use technology is tested for in the exam for given use scenarios.
EP8m	The effect of measurement error, parameter tolerances and input-output voltage swing is discussed. Best-guess initial approach to develop the necessary power electronics required for power transfer is described and developed to optimise efficiency. Input-output characteristics would be given in an exam and the necessary constraints/design decisions to be imposed would be expected.
EP9m	The students are exposed to current practice within the course, usually from a guest lecture usually given by a part-time PhD student who has experience of modern Switched-mode power supplies. Appreciation of good practice and limitations of technologies is tested for in the exam.
EP10m	This is also covered by examples given in the guest lecture on the design of a commercial SMPC. The ability to exploit these ideas is tested in the exam.