POWER ELECTRONICS - 2024/5

Module code: EEE3026

Module Overview

Expected prior learning: Modules EEE2033 – Circuits, Control and Communications, or equivalent learning. Knowledge of linear systems and of the basics of control engineering is particularly helpful.

Module purpose: This module aims to develop a better understanding of transistor amplifiers, power semiconductor switching devices and various power converters. A detailed analysis of power converters like AC to DC phase controlled rectifiers, AC to AC, DC to DC converter & Pulse Width Modulated (PWM) inverters will be provided. In order to develop a broader understanding of this subject, a few domestic & industrial applications will be taught in this module.

Module provider

Computer Science and Electronic Eng

Module Leader

SPOREA Radu (CS & EE)

Number of Credits: 15

ECTS Credits: 7.5

Framework: FHEQ Level 6

Module cap (Maximum number of students): N/A

Overall student workload

Independent Learning Hours: 96

Lecture Hours: 11

Tutorial Hours: 11

Guided Learning: 10

Captured Content: 22

Module Availability

Semester 2

Prerequisites / Co-requisites

None.

Module content

Power Semiconductor Switches and related electronic devices: Concept of power electronics, Basic structure, Switching characteristics and I-V characteristics of Thyristors, GTOs, Triacs, Diodes and Zener Diodes, BJTs and Design examples.

Transistor amplifiers: CE, CB and CC configuration; AC and DC models and analysis; input and output impedances; coupling and decoupling; tuned amplifiers; multistage amplifiers. Design Examples.

Other transistor circuits: current mirrors; differential stages; linear regulators. Design examples.

AC to DC Phase Controlled Rectifiers: Principle of phase control, Single-phase half-wave & full-wave converters, Semi-converters and Design Examples

Practical AC to DC Rectifiers: Dual converters, Three-phase converter system using diodes, Three-phase full bridge rectifiers and Design Examples.

DC to AC Converters: Single-phase voltage source bridge inverters, Pulse-Width Modulated inverters and Design examples.

DC to DC Converters: Principles of operation, Control strategies, Types of Choppers, Practical switched mode converters, Buck converter, Boost converter, Buck-Boost Converter and Design examples.

AC Voltage Converters: Types of ac voltage controllers, Single-phase voltage controller and Design examples.

Feedback Control for Converters: Converter models for feedback, Voltage-mode & current-mode controls for DC to DC converters, Introduction to state-space modelling for converters.

Applications: Voltage regulation, Contactors, Uninterrupted power supplies, Introduction to HVDC transmission, A case study: Cross-channel HVDC link.

Assessment pattern

Assessment type	Unit of assessment	Weighting
Examination	Closed book examination 2hrs	100

Alternative Assessment

N/A

Assessment Strategy

The assessment strategy for this module is designed to provide students with the opportunity to demonstrate the learning outcomes, focusing on analytical, problem solving, and lateral thinking skills. This includes background understanding of amplifiers, electrical power systems and power conversion techniques and extend of transferable and professional skills that are relevant to the power industry.

To aid students' development of required skills in identifying and applying suitable engineering approaches to the design and analysis of power converters and transistor amplifiers, formative assessment and feedback will take place within each main section of the module, taking the form of:

- questions/answers and discussion during lectures, targeting the fundamental concepts and engineering judgement of suitability of design and analysis approaches

- group discussion on design/analysis challenges during tutorial sessions

- individual practise of design and analysis tasks following worked-out examples

Students will participate actively and frequently do discussions spanning design decisions, engineering judgement, critical appraisal and suggested improvements to proposed design, aspects of sustainable implementation and energy efficiency.

Summative assessment will consist of a 2-hour closed-book invigilated examination, covering broad fundamental concepts and testing the student's timely application of design and analysis ability. Successful students will demonstrate the ability to adapt and offer viable technical solutions in a time- and information-constrained environment. To reflect real-world decision making in designing electronic circuits with prioritised sets of specifications, engineering judgement and the articulation of design trade-offs will be assessed, including dimensions of performance, design complexity/cost, reliability and sustainability.

Module aims

- The module introduces analogue electronic device operation, including transistor amplifiers and power electronic switching devices. It covers power conversion techniques for various domestic and industrial applications.
- The module also aims to provide opportunities for students to learn about the Surrey Pillars listed below.

Learning outcomes

Ref		Attributes Developed	
003	Evaluate the basic operations of power semiconductor switches used for power conversion	KC	C2
004	Apply the basic principles of power electronics switching devices for designing converters	KC	C5
005	Analyse and design AC to DC, DC to AC, DC to DC and AC to AC converters.	KCPT	C5, C6
006	Demonstrate an understanding of power conversion techniques for various practical applications.	KC	C6
001	Analyse and design simple transistor circuits utilising their static and dynamic characteristics.	KC	C5
002	Demonstrate the features and application of a range of transistor circuit configurations. Discuss respective circuit limitations and constraints.	KC	C2

Attributes Developed

C - Cognitive/analytical

K - Subject knowledge

T - Transferable skills

P - Professional/Practical skills

Methods of Teaching / Learning

The module gives an introduction to power conversion and signal amplification theory and practice. Students will draw on their prior knowledge of transistor amplifiers, semiconductor device operation, digital vs analog electronic design, control engineering. By focusing on the fundamental circuit topologies, as well as application-driven circuit design and analysis, the content complements module EEE3038 (Electrical Machines and Power Systems) which runs in parallel.

The learning and teaching strategy is designed to achieve the following aims:

- To develop confident and adaptable engineers who are able to integrate and apply knowledge to the analysis, fault finding, design and optimisation of power electronics applications including power converters and amplifiers
- To further develop student's awareness of the multifaceted and often conflicting dimensions of electronics design including performance, cost, energy efficiency, ecological and lifetime/reliability
- To give students the ability to practice problem solving and design skills individually and in small groups, reflecting the requirements of the engineering profession
- To inform and to allow students to question the practices of modern power electronics engineering via discussions, interactions and case studies led by leading industry professionals

Learning and teaching methods are chosen to reflect the many facets of electronic engineering design. As such, they include the following:

- Hour-long in-person lectures on the subtopics of the module, and designed to encourage peer discussion and feedback
- Bite-sized pre-recorded content and detailed lecture notes aimed at independent learning
- In-person tutorials focused on problem solving, case studies and discussion of engineering challenges
- Guest lectures and discussion sessions from industry
- Visualisation and sensory experience to correlate electronic circuit mathematical analysis and physical behaviour
- In-class review of taught material during revision week

Indicated Lecture Hours (which may also include seminars, tutorials, workshops and other contact time) are approximate and may include in-class tests where one or more of these are an assessment on the module. In-class tests are scheduled/organised separately to taught content and will be published on to student personal timetables, where they apply to taken modules, as soon as they are finalised by central administration. This will usually be after the initial publication of the teaching timetable for the relevant semester.

Reading list

https://readinglists.surrey.ac.uk
Upon accessing the reading list, please search for the module using the module code: EEE3026

Other information

Modern engineering requires awareness of multiple areas that complement the specialist focus. The module provides students the opportunity to increase their proficiency in several skills essential to the adaptable, efficient, and technically skilled engineer.

Employability

The module is an introduction to power electronics and signal amplification. Students will develop engineering skills, including: problem solving, efficient design and arriving at an acceptable solution within resource constraints, multi-parameter optimisation, awareness of sources of non-ideality and applicability of approximations, ability to work independently and with others, ability to articulate and justify own design decisions, proficiency in solving unseen challenges by applying prior experience and engineering judgement. These complement the module content, which includes fundamental circuit design and analysis for power systems to develop skills that are widely applicable to areas of growth: sustainable energy generation and storage, efficient use of energy, electric vehicles, balancing design trade-offs for wearable and mobile electronics.

Sustainability

Energy efficiency is the core precept of the module. Throughout the module, students will be exposed to challenges of balancing several competing aspects of engineering designs, and will develop the skills to effectively apply their awareness of the various trade-offs in the design of systems that meet technical specifications while operating efficiently (for example minimising the number of components used, using switched vs. linear power regulators, etc.). Industries taking advantage of these engineering skills include clean energy, electric vehicles, and wearable electronics.

Global and cultural capabilities

Engineering teams are diverse and geographically dispersed. Several activities within the module are designed to promote interaction, problem solving in groups, dialogue with specialists abroad and an awareness of varying priorities in engineering design based on geography, climate and broader context. Students will continue to develop their communication and teamworking abilities. As many in the cohort will be returning from placement, the collective experience enabled by the individual development during placement will promote sharing of best practices and application of learning and strategies originating from multiple sources.

Resourcefulness and resilience

While the module is an introduction to power electronics and signal amplification, it provides a solid basis on which to build advanced and specialist skills. Both the learning & teaching and assessment strategies are designed to challenge students to develop their ability to integrate learning and to synthesise design and analysis strategies which are widely applicable to modern engineering problems. By successfully solving practical engineering problems, students will continue to develop attributes such as problem solving and decision making, engineering judgement when faced with conflicting sets of requirements, confidence, adaptability. They will have ample opportunity to demonstrate their agency within the learning process, and to acquire resilience and adaptability bolstered by the reflection on their continued development as successful problem solvers. This dimension of the students' learning will be supported via guided discussion and reflection, reinforcing connections with technical and developmental learning in related modules and structured learning with opportunity for adequate levels of stretch/challenging/unseen experiences.

Programmes this module appears in

Programme	Semester	Classification	Qualifying conditions
Electrical and Electronic Engineering BEng (Hons)	2	Compulsory	A weighted aggregate mark of 40% is required to pass the module
Electrical and Electronic Engineering MEng	2	Compulsory	A weighted aggregate mark of 40% is required to pass the module
Electronic Engineering BEng (Hons)	2	Optional	A weighted aggregate mark of 40% is required to pass the module

Programme	Semester	Classification	Qualifying conditions
Electronic Engineering MEng	2	Optional	A weighted aggregate mark of 40% is required to pass the module
Electronic Engineering with Computer Systems BEng (Hons)	2	Optional	A weighted aggregate mark of 40% is required to pass the module
Electronic Engineering with Computer Systems MEng	2	Optional	A weighted aggregate mark of 40% is required to pass the module
Electronic Engineering with Nanotechnology BEng (Hons)	2	Optional	A weighted aggregate mark of 40% is required to pass the module
Electronic Engineering with Nanotechnology MEng	2	Optional	A weighted aggregate mark of 40% is required to pass the module
Electronic Engineering with Space Systems BEng (Hons)	2	Optional	A weighted aggregate mark of 40% is required to pass the module
Electronic Engineering with Space Systems MEng	2	Optional	A weighted aggregate mark of 40% is required to pass the module