ELECTRICAL MACHINES AND POWER SYSTEMS - 2024/5

Module code: EEE3038

Module Overview

This module aims to introduce the operating principles of electrical machines used in the power stations. Further this module will cover to a greater depth the concept of power transmission using interconnected grid systems, overhead and underground power transmission and distribution systems. This module is primarily intended for students on an Electrical engineering pathway but is widely available to students on other pathways so that they may get some exposure to the engineering achievement and challenges of large-scale electrical machines (generators, motors and transformers) and the operation of the power grid.

Module EEE3038 Electrical Machines and Power module builds upon the electromagnetic theory covered in Level 5 module EEE2045 Electrical Science II. It shows how this leads to the design and understanding of the operation of large electrical (AC) machines – motors, generators and transformers. The module is complementary to the Level 6 module EEE3026 Power Electronics, which deals primarily with circuit level devices.

Together, these modules provide a good understanding of AC electricity for students who wish to embark on a career in the electrical power industry. For students on the MEng electrical pathways, the material covered in these modules provides the fundamental knowledge required for the compulsory Level 7 modules: EEEM058 Renewable Energy Technologies and ENGM246 Wind Energy Technology. Students graduating from these programmes are well set up for careers in the burgeoning “green” industries.

Module provider

Computer Science and Electronic Eng

Module Leader

UNDERWOOD Craig (Elec Elec En)

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: 88

Lecture Hours: 11

Tutorial Hours: 11

Guided Learning: 10

Captured Content: 30

Module Availability

Semester 2

Prerequisites / Co-requisites

None

Module content

Indicative content includes:

Each lecture is accompanied by directed reading, detailed notes with exercises, summary "key notes" and digital content aimed at reinforcing the learning and shown actual industrial practice across the world (Employability, Global and Cultural Intelligence).

AC electricity behaves in a fundamentally different way to DC electricity, and its behaviour cannot be understood without reference to vector and matrix mathematics and the manipulation of complex numbers. Students should make sure that they revise such mathematics taught in earlier modules (EEE1031, EEE1032, EEE2035) or consult a standard Engineering Mathematics textbook such as: K.A. Stroud "Engineering Mathematics", Macmillan, 2020.

Fundamentals of AC Power: The sinusoidal nature of AC current and voltage and how these combine to produce power. RMS values; Real, Apparent and Complex Power; Power Factor; Three-Phase Power.

AC Sources and Loads: AC generators; Faraday's Law; 3-phase generators; line-to-line and line-to-neutral voltages; Wye and Delta Configurations; Balanced Loads.

AC Power Measurement: Phase Sequence; measuring Real (Active) Power (W) (wattmeters); measuring Reactive Power (VAR) (varmeters); measuring Power Factor; current transformers and potential transformers; rebalancing 3-phase systems; synchronous generators; size effects.

Synchronous Reactance: The per unit (PU) system; synchronous generator under load; single generator; regulation.

Synchronisation and Grid Connection: The infinite bus; over and under excitation; mechanical torque and active power delivery; AC active power transfer between systems; transient reactance;

Ideal Transformers: Primary and secondary coils, dot notation, phase relationships; Magneto-Motive Force (MMF); Impedance ratio; circuit equivalents.

Practical Transformers: Imperfect Core, primary and secondary flux losses; polarity markings; transformer rating, efficiency and cooling; real transformers; coupling transformers. Industrial examples are given in the digital video content. [Employability Global and Cultural Intelligence]

Special Transformers and 3-Phase Transformers: High impedance transformers and applications; high frequency transformers; autotransformers; 3-phase transformers.

Generation of Electrical Energy: Energy requirements; hydro power; pumped storage; thermal/nuclear power stations; pollution control; reactor types; nuclear waste; nuclear fusion; wind power; solar photo-voltaic power [Not Examined] – these notes are for background reading on the various power options available for general discussion and debate in class. [Sustainability, Global and Cultural Intelligence] Students are encouraged to do their own reading on these topics and be able to debate the topics in a respectful way with other students [Resourcefulness, Resilience].

Transmission of Electrical Energy: Form and nature of the electrical power transmission system (the grid) and its technologies and voltage levels; engineering issues – e.g. wind, ice, lightning, noise, electro-magnetic interference; power transfer between systems; aerial and underground lines; compensated inductive lines. The 1989 solar super storm and the Carrington Event – how would we cope today? [Resilience]

Direct Current (DC) Transmission: Advantages of DC; Basics of DC power transmission (model system); bipolar DC transmission (Digital content – the ultra-high voltage DC power grid in China) – how the modern world is moving to UHVDC systems to send power over continental distances. [Employability, Global and Cultural Intelligence].

Electrical Power distribution: Form, voltages and technologies of the local power distribution system; methods of protection; Electrical safety.

Assessment pattern

Assessment type	Unit of assessment	Weighting
Coursework	DESIGN EXERCISE (MATLAB/SIMULINK)	20
Examination	2 HOUR CLOSED BOOK EXAM	80

Alternative Assessment

N/A

Assessment Strategy

The assessment strategy is designed to provide students with the opportunity to demonstrate their analytical skills, background understanding of the subject, problem solving skills as well as identify any transferable skills that are relevant to the power industry.

Thus, the summative assessment for this module consists of:

- Coursework: MATLAB/Simulink Design Exercise. This allows students to apply their knowledge to a practical design problem involving Digital Capabilities [MATLAB, bespoke power grid simulation software and modelling tools] [LO5]

- Exam. The exam paper will be designed to test students' theoretical knowledge as well as problem solving skills related to the learning outcomes of this module {LO1-LO7]

Formative assessment and feedback

Students will get verbal feedback after each problem-solving sessions/tutorials. They will also get feedback via the coursework assessment.

Module aims

- To introduce the key principles of electrical machines, power generation and transmission
- To introduce the power distribution systems and interconnected grid systems.
- To provide students with the opportunity to gain practical design experience through MATLAB/Simulink simulation

Learning outcomes

Ref		Attributes Developed	
001	Explain the operation of AC generators and transformers and its applications for power systems	KC	C1, C2
002	Describe the basic operation of AC and DC power transmission and distribution systems	KC	C1, C2
003	Demonstrate an understanding of the operation of interconnected grid systems	KT	C6
004	Compare the suitability of overhead and underground transmission systems	C	C7
005	Apply the theoretical knowledge to workout design problems on power generation, transmission and distribution systems including by simulation	PT	C6
006	Describe the basic principles of operation of a range of electrical machines.	KCT	C2
007	Demonstrate a basic competence in performance calculations for generators, DC machines, transformers and induction motors.	KCPT	C3, C16, C17

Attributes Developed

C - Cognitive/analytical

K - Subject knowledge

T - Transferable skills

P - Professional/Practical skills

Methods of Teaching / Learning

The learning and teaching strategy is designed to: include regular lectures. These lectures will include the problem solving sessions

Lecture/tutorials

Revision will take place in Week 11. Lecture notes will be provided and students are expected to do independent learning in addition to attending lectures and tutorials. In addition, a MATLAB/Simulink exercise is included on microgrid power system design.

The learning and teaching methods include:

- Lectures which include class discussion and problem solving sessions.
- in-class revision in Week 11.
- MATLAB/Simulink design exercise.

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: **EEE3038**

Other information

This module contains substantial coursework involving the use of computer models to simulate an electrical power grid. This builds up **digital capabilities** through writing MATLAB models and using commercial power simulation software tools (POWERWORLD). The exercise requires the student to produce a professional report, which aids their **employability**.

Sustainability – The module discusses renewables and nuclear power as well as traditional fossil fuel power generation – the pros and cons of each are discussed in tutorial sessions with non-examined material presented. The challenges to the National Grid are also discussed as we move to "Net Zero".

Global and Cultural Intelligence – The module uses examples from around the world, and, in particular, discusses the engineering practice in India (with video examples), and the advanced DC grid developments in China. European international cooperation is discussed in terms of power sharing and coordination.

Digital Capabilities – This module is more concerned with heavy electrical engineering rather than light digital electronics – however, the control of the grid systems is toughed upon as is the need for more advanced control for HVDC systems which is a major development area. In the coursework, the students do a modelling exercise and learn the power of mathematical modelling and computer simulation.

Employability – The industrial context is given throughout, with video demonstrations of actual working practices in power generation and grid management. Students are strongly encouraged to enter this area of electrical engineering due to the huge shortage of qualified engineers we have in the UK in this area.

Resourcefulness and Resilience – The coursework is highly structured and enables the student to work individually to build up their resourcefulness and digital software skills.

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 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