Electrical Machines and Power Electronics

Module Guide

ENG_5_524

http://vle.lsbu.ac.uk/

Module Co-ordinator: Dr Fang Duan

School of Engineering

Level 5

Contents

1. Module Details

Module Title:	Electrical Machines & Power Electronics
Module Level:	5
Module Reference Number:	ENG_5_524
Credit Value:	20
Student Study Hours:	200
Contact Hours:	52; 24 lecture, 12 workshop, 4 revision+12 Tutorial
Private Study Hours:	148
Pre-requisite Learning (If applicable):	ENG_4_404; ENG_4_401
Co-requisite Modules (If applicable):	None
Course(s):	MEng/BEng Electrical Engineering & Power Electronics; MEng/BEng Electrical & Electronic Engineering
Year and Semester:	2019-S1
Module Coordinator:	Dr Fang Duan
MC Contact Details (Tel, Email, Room)	duanf@lsbu.ac.uk
Teaching Team & Contact Details (If applicable):	Dr. Fang Duan; Peter Adams; adamsp6@lsbu.ac.uk
Subject Area:	Electrical & Electronic Engineering
Summary of Assessment Method:	Examination 70%; Coursework 30%
External Examiner:	Prof Ghanim Putrus; University of Northumbria
Provenance:	This module comprises material on power electronics and basic electrical machines introduced to improve preparation for L6 modules and because of building services student's employers requests for better coverage of this area. The content has been updated to conform to evolving university standards, technical changes, pedagogical developments and during course revalidation and review, and approved at Subject Reviews etc.

2. Short Description

This level 5 module adopts a modern approach to the study of electrical machines, three-phase transformers and power electronic converters. The treatment emphasises the features

common to all types of electrical machines and power electronic converters and then develops basic performance equations and equivalent circuits and applies them to common electrical machines and power converters in current use. The associated laboratory workshop features work on typical electrical machines and power converters.

3. Aims of the Module

This module aims to provide students with a basic physical and mathematical understanding of electromechanical energy conversion and power electronics and the operating characteristics and performance behaviour of common electrical machines and power converters in steady state.
The module provides sufficient coverage and a motivation for more advanced treatment of machines and power electronics in subjects such as electrical services and lighting, power systems, electrical energy converters and drives, control systems, robotics and mechatronics.

4. Learning outcomes

4.1 Knowledge and Understanding

- Be able to distinguish between the main classes of electrical machines and the unifying features underlying electrical machines
- Be able to distinguish between the various classes of phase controlled and chopper circuits and describe their performance characteristics
- Know how electro-motive force (EMF) and torque are produced by different types of machine windings and be able to distinguish between the various emf's and torques
- Understand the action and properties of electrical machines in the steady state
- Know the basic analytical models and equivalent circuits used for the main types of machines and converters
- Be aware of new developments in machines and power electronics technology
- Know the different types of three phase transformer connections and the rules and behaviour when transformers are connected in parallel

4.2 Intellectual Skills

- Be able to perform performance calculations for the main classes of machine and converters and appreciate their uses and limitations
- Perform simple simulations for electrical machines using performance models

4.3 Practical Skills

- Organise and conduct test measurements to obtain operating characteristics of electrical machines and power electronic converters

4.4 Transferable Skills

- Produce a concise, systematic and well structured report requiring organisation and analysis of data and critical appraisal of results
- Know the characteristics and how to use appropriate modern measuring instruments

5. Assessment of the Module

There are two components of assessment – an examination (component 1) and coursework (component 2). The minimum pass mark for the module is 40% and you must obtain a minimum mark of 30% in each component.

5.1 Examination

An unseen written examination at the end of the module which will contribute to 70% of the module mark, see the table below. The university's examination rules apply and you must make yourself familiar with these.

5.2 Coursework

An open-logbook **Workshop Test** (max 1Hr) **in semester 1 wk 13** (Thur 9 January 2020) and **logbook submission (deadline on Thur 9 January after the workshop test)**, contributing to 30% of the module mark, see the table below. An attendance record is kept for the workshop.
Please submit the logbook in the usual way, via the school office, in T-313 on my name – Fang Duan.

Assessment Component	Type of assessment	Timing of assessment	Contribution to module mark
1	Examination	End of module	0.7
2	Workshop Test & Laboratory log book submission	Test & Logbook in semester 1, week 13	0.3

All deadlines should be strictly met, otherwise you run the risk of losing part or all of the marks for work submitted late.

5.3 Coursework Assessment Criteria

Logbook/workshop test
Marks awarded for:

- maintaining an accurate, full and chronological record of your work
- exercises completed and questions answered
- tabulating your results and data if appropriate
- using the correct units
- accuracy and clarity of results & analysis
- the provision of brief conclusions
- the quality of presentation and structure of your log book; dating your work
- provision of contents list in the front

Marks may be deducted for:

- missed work, failure to document work
- poor presentation and inadequate 'signposting'
- failure to submit by the deadline
- copying (plagiarism) from others logbook entries and explanations/answers

6. Feedback

Feedback will normally be given to students in line with the School's policies, which is 15 working days after the submission of an assignment.

7. Introduction to Studying the Module

7.1 Overview of the Main Content

NB. the material will not necessarily be covered in this order in the lectures.

- Three phase power transformers. Terminal markings, vector groups, paralleling and load sharing, tap changing, 3-winding transformers. Operation: cooling, losses, efficiency, cyclic loading, cost of ownership, inrush current.
- Electrical machine principles: torque production in singly and doubly excited transducers, winding types, mmf and emf produced by windings. Time and space harmonics.

- Voltage equations, torque equations, equivalent circuits for dc machines, synchronous machines, induction machines in steady state. Other electrical machine types.
- Starting, braking, testing. Utilisation: ratings, specific loading, duty classes, insulation classes.
- Converter principles: generalised switching circuits, functional components of converters.
- AC – DC converters: single phase uncontrolled/controlled rectifier circuits, operation and characteristics. Synchronous inversion. Equivalent circuits.
- DC - DC converters. Basic step down/up converters. Operation and characteristics.

7.2 Overview of Types of Classes

7.2.1 Lectures

The taught material will be covered by lectures supported by notes available on the module BB site. Lectures will be two hours per week with a short break about halfway. Past exam questions are normally attempted as in-class tutorials. In the non-contact time, you will be expected to assimilate the lecture material and attempt the tutorial questions. You must organise yourself so that you have at least around 5 hours per week of your own time to do the tutorial problems, self-check on your understanding of the material just covered and prepare for the next sessions of lecture and workshop. This time should be increased as the examination approaches.

7.2.2 Workshop Sessions

You will be divided into groups for the laboratory. A separate laboratory timetable will be produced. In the workshop sessions in T120/T135 you will each have six- 2-hour sessions. The first session is a demo week and you will work on FIVE workshop exercises. Owing to the limited time you will need to work quite fast to get through each exercise; reasonable progress will be expected. Instruction sheets for the exercises are grouped in a separate bound workshop manual with additional notes on the organisation of the workshop. Before each scheduled workshop session you should ascertain from the timetable which exercise you are scheduled to do and read through the instructions in the workshop manual BEFORE you attend the workshop session to become familiar with the contents. This will save time and reduce the likelihood of procedural errors on the day. An attendance register will be taken in the laboratory. Also please touch in your ID card at the attendance registering points in the workshops.

7.3 Importance of Student Self-managed Learning Time

In the private study time your main tasks are to assimilate the lecture material, attempt the tutorial questions, and manage the upkeep of material in your log book. To succeed in this and get the most from the module, you will need to exert good self-discipline to manage your private study time effectively particularly as you will be studying another level 2 modules at

the same time. I offer some suggestions below to aid you in this (see also the Study Skills Survival Guide available from the Study Skills Centre).

General:

- Always try to re-read the lecture material within 24 hours of the lecture - retention will be helped if the material is still fresh in your mind.
- Plan the pace of your studies with great care and coordinate across modules so that you are not left with a large amount of work to do in the last few weeks when you should be concentrating on the revision of the material.
- Try to get into regular study habits at set times and places. Find out when and where you best study and optimise the arrangements for this. For example, find sufficient space for your papers with preferably a dedicated table so that papers do not continually have to be cleared and material for individual modules can be easily accessed and filed.
- Try to minimise external disruptions when you study but give yourself time for rest periods and food.

Before each lecture/workshop session you should:

- Consult the course notes and read the lecture material.
- Consult the laboratory rota in the Workshop Manual to find out which exercise you will be attempting and peruse the instruction sheet to get an overall view of what you will be doing.

After each lecture you should:

- Re-read the material within 24 hours.
- Attempt tutorial and past examination questions on the lecture topic doing any further reading as necessary to improve your understanding.

After each workshop session you should:

- Ensure that any printouts are correctly positioned in the log book and questions posed by the instruction sheet are answered. Draw up any comparison tables needed and try to take an overview of what has been achieved. Write a short conclusion at the end of each exercise.

7.4 Employability

In this module, you will continue to develop skills relating to logbook upkeep, in particular, the techniques for presenting comparative results and observations. When completing the Formal Report you will also develop skills required to produce a considered written description of a technical exercise including presentation, analysis and discussion of results.

Practical skills include wiring circuits from a schematic diagram, use of an oscilloscope for measurements on non-sinusoidal waveforms, use of virtual instruments for measuring and recording. You will also be exposed to individual types of electrical rotating machines, transformers and power electronic converters.

8. The Programme of Teaching, Learning and Assessment

Study week	Topic in lecture slot
1	1. Three phase transformers
2	1. Three phase transformers (continued)
3	1. Three phase transformers (continued)
4	2. Fundamentals of phase controlled rectification Introduction (Half wave uncontrolled rectification)
5	2. Fundamentals of phase controlled rectification Introduction (Full wave uncontrolled converters)
6	2. Fundamentals of phase controlled rectification Introduction (Single phase controlled converters)
7	2. Fundamentals of phase controlled rectification Introduction (DC - DC converters)
8	3. Electrical machine principles and windings (Electromagnetic force production and torque)
9	3. Electrical machine principles and windings (Production of stationary and rotating magnetic fields)
10	4. Induction machines
11	4. Induction machines (continued)
12	5. Synchronous machines
13	Workshop Test and Revision

The module co-ordinator reserves the right to change the order of the delivery as deemed necessary.

Your previous study should have enabled you to gain knowledge of:

- single phase transformers to the level of the approximate equivalent circuit.
- basic diode and transistor behaviour.
- basic a.c and d.c. electrical circuits in the steady state and simple first order transients.
- magnetic circuits and self and mutual inductance.

Note: You will find 4 coloured pens useful in some of the lectures. This programme allows lectures to finish in week 12 (or week 13 if there is overrun for any reason) to give one week for revision.

9. Student Evaluation

- If possible try to reduce lab group sizes to 3 students. Maintain the supervisor/student ratio.
- Give instruction on logbook upkeep and workshop test.
- Arrange a field trip.

10. Learning Resources

10.1 Core Materials

There is no one textbook that covers all the material in this module at a consistent level: machines texts tend to have limited coverage of power electronics and vice versa. For this reason comprehensive course notes are provided which cover the material at a suitable level. The following two recommended books for the module give about the best all round coverage at this level, although some material is covered rather briefly, for example 3-phase transformers:

- Electric Machines and Electromechanics. S. Nasar. Published by McGraw-Hill (Schaum's Outline Series), second edition, 1997, 224p. ISBN: 978-0070459946
- Power Electronics. C. W. Lander. Published by McGraw-Hill, 3rd edition, 1993, 496p. ISBN: 9780-77077143

The following book used to be the recommended text but is now out of print, I believe - there may be copies in the library or publisher's remainders.

- Basic Electrical Power & Machines by D.A. BRADLEY Published by Chapman & Hall, 1994, 203p. ISBN: 978-0412455407

10.2 In House Support Materials

The following materials are provided for learning support in the module:

- Module Guide (this document!). This contains details on how the module is organised and assessed and a weekly teaching and learning schedule. A copy is available on the module BB site.
- Course Notes (lecture notes). These are available on the module VLE site.

- Workshop Manual. This contains an introduction and explanation of the organisation of the workshop, the individual groups timetable rota, an introduction to keeping a log-book, and the instructions for the workshop exercises. One copy given to each person studying the module.
- Website. See section 10.3 below

10.3 VLE Website

We will be using "Moodle", a web-based Virtual Learning Environment (VLE) to support learning activities on this module. The VLE contains space to put announcements and course information, downloadable learning materials, assignments, module guides, discussion boards and chat rooms, email hosting assessment tests and questionnaires. Students log onto Moodle using their LSBU Username and LSBU Windows password. Students who have LSBU computer accounts and are enrolled onto courses/modules will automatically be connected to Moodle sites supporting their areas of study. The university Moodle site can be accessed at: http://vle.lsbu.ac.uk/ .

10.4 Optional Materials

The following books tend to provide good coverage in either power electronics or machines, but not both, but make good supplementary/further reading:

1. Principles of Electric Machines and Power Electronics. P. C. Sen. Published by John Wiley & Sons, Third edition, 618p. ISBN-10: 111807887X,
2. Power Electronics. D. A. Bradley. Published by CRC Press, second edition, 224p. ISBN: 0-412-57100-5
3. Hughes, A and Drury,B . Electric Motors and Drives, 4th ed. Published by Newnes, 2013. ISBN: 0080983324
4. Electric Machines. M. S. Sarma. Published by West Publishing Co. (c/o International Book Distributors), second edition, 1994, 649p. ISBN: 0-314-01226-5
5. Solving Problems in Electrical Power & Power Electronics. H. F. G. Gwyther. Published by Longman, 1988, 203p, ISBN: 0-582-28644-1

Dr. F. Duan Sep. 2019