LONDON SOUTH BANK UNIVERSITY

unit guide

Electrical Fundamentals

EPR-1-803

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Faculty of Engineering, Science and the Built Environment

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UNIT DETAILS

Unit Title:	Electrical Fundamentals
Unit Level:	1
Unit Reference Number:	EPR-1-803
Credit Value:	15
Student Study Hours:	150
Contact Hours:	52; 24 lecture, 18 workshop, 6 tutorial, 4 revision
Private Study Hours:	98
Pre-requisite Learning (If applicable):	Qualifications for first year engineering degree programmes
Co-requisite Units (If applicable):	
Course(s):	BEng EEE, BEng TeCNE
Year and Semester	Y1, S2
Unit Coordinator:	Dr R R Pettitt
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Teaching Team & Contact Details (If applicable):	Mr A Howson, x7510; howsona@lsbu.ac.uk , T407 (lec/tut) Mr M Ponugubati, x7523; ponugubm@lsbu.ac.uk , T610 (lec/tut) Dr P Ridler, x7577; ridlerpj@lsbu.ac.uk , T610 (lab)
Subject Area:	Electrical Engineering
Summary of Assessment Method:	Examination 70%; Coursework 30%
Provenance:	This level one unit is a combination of parts of two former level 1 units on the BEng EEE programme. It is a core unit on some of the BEng programmes in the Electrical & Electronic Engineering course cluster. Unit guide layout revised to comply with QU template 2005/6.

1.0 SHORT DESCRIPTION

This is a level 1 technology unit covering the electrical and circuits parts of the fundamentals of electrical and electronic engineering. Its aim is to introduce important concepts and develop your understanding of basic principles as a foundation for the analysis and design of modern electrical systems and projects. There is an integrated laboratory workshop to reinforce the lecture topics.

2.0 AIMS OF THE UNIT

This level 1 unit introduces some standard methods and techniques for the application of basic lumped parameter steady-state models for d.c. single and three phase a.c. circuits, including magnetically coupled circuits and transformers. The emphasis is on techniques that enable the problem to be posed in a generic way to enable solution by computers You will study essential fundamental physical concepts and apply this knowledge to solve practical problems.

You should already have working knowledge of the following topics:

- algebraic equations and manipulation, complex number representation
- basic physical phenomena of electricity and magnetism and the basic units of voltage, current and flux
- fundamental relations between force, power and energy

3.0 LEARNING OUTCOMES

Note: these learning outcomes were developed before the following categories were specified. Some of them may therefore overlap across the four specified categories.

All outcomes have **"At the end of the course students will be able to: "** preceding.

3.1 Knowledge and Understanding

- rigorously apply reference directions to voltage and currents in a circuit when the actual polarities are not known a-priori and proceed to solve the circuit, then using the Passive sign convention to work out the correct polarities
- know when and how to apply one of the methods from the following which gives the simplest computation. Equivalent circuits to series and parallel combination of circuit elements, source transformations, Thevenin and Norton equivalent circuits, Kirchoff's Current and Voltage Laws, the Node-Voltage analysis method, and the Mesh-Current analysis method
- understand the action, properties and use of transformers in electrical circuits and perform calculations using the simplified equivalent circuit

3.2 Intellectual Skills

- apply the above methods to purely resistive circuits driven by DC sources
- apply the techniques of phasor analysis and $j\omega$ notation to circuits containing resistance, reactance and sinusoidal sources to find the impedances, voltages, currents and the complex power flows in both single phase and balanced three phase circuits

3.3 Practical Skills

- use relevant test and measuring equipment to make electrical measurements on d.c. and a.c. single-phase circuits and obtain circuit parameters from resulting calculations
- design, build and test a simple electrical winding

3.4 Transferable Skills

- keep a detailed technical logbook
- be aware of safety issues
- organise, manipulate and present data

4.0 ASSESSMENT OF THE UNIT

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

4.1 Examination

A **two** hour unseen written examination at the end of the unit which will contribute 70% of the unit mark, see the table, item 1 below. The university's examination rules apply and you must make yourself familiar with these.

4.2 Coursework

The laboratory logbook will contribute 30% of the unit mark, see the table below. The laboratory logbook must be handed in by **Week 13**. An attendance record is kept for the workshop sessions. An attendance record is kept for the workshop sessions.

Assessment Component	Type of assessment	Timing of assessment	Length	Contribution to unit mark
1	Examination	End of unit	2 hours	0.7
2	Workshop log book	Every session and week 13		0.3

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

4.3 Coursework Assessment Criteria

Laboratory Logbook	
Marks awarded for: • maintaining an accurate and chronological record of your work as it is carried out • exercises completed and questions answered • clear graphs with correctly labelled axes and titles, and experimental points clearly shown • tabulating your results and data if appropriate • using the correct units • accuracy and clarity of results and analysis • the provision of brief conclusions • quality of the presentation and structure of your log book; dating your work • provision of a 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	

5.0 INTRODUCTION TO STUDYING THE UNIT

5.1 Overview of the Main Content (syllabus)

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

Fundamentals of electrical circuits: Ohm's Law. Kirchoff's laws. Thevenin, Norton theorems. Superposition. Maximum power transfer.

DC network analysis: Node and mesh analysis.

Sinusoidal steady-state analysis: single phase circuits, balanced 3-phase circuits, power relationships, complex power.

Magnetically coupled circuits and transformers: mutual inductance, coupling factor, principles of operation, ideal transformers, equivalent circuits, testing and efficiency.

5.2 Overview of Types of Classes

Lectures

The taught material will be covered by lectures supported by printed notes which will be given out in the first session. The material divides into 2 equal parts containing electrical material and circuits material each having a separate one hour per week lecture. *In the non-contact time you are expected to read through and assimilate the lecture notes and attempt tutorial questions. You must organise yourself so that you have around 6 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 lecture*. This time should be increased as the examination approaches.

Tutorial questions and sessions

You will be divided into groups for the tutorials. Each group receives one 1-hour tutorial per week alternating between the electrical and circuits lecturers. Tutorial sheets and past examination questions will be provided.

You are required to keep a bound **Tutorial logbook** in which you must record ALL the work that you do during the tutorial sessions plus the working out of solutions to drill problems and past examination papers that will be given to you. You should attend your timetabled tutorial class where the supervisor will have the solutions and will cover any question or concept you find difficult. *Please prepare for these tutorials by attempting questions and noting your problems beforehand* so that time is not wasted by covering problems that you can solve. Attendance at tutorials is expected; individuals attendance may be reported to the exam board.

Workshop sessions

The integrated laboratory sessions feature sequential exercises on:

- DC and AC circuits, measurements & safety

- Self/mutual inductance, magnetic circuits
- Transformer construction and testing

The instruction sheets are grouped in a separate workshop manual with additional notes on the workshop organisation. *Read the relevant instructions in the workshop manual **BEFORE** attending each workshop session* so that you are well prepared. You must use a bound **Laboratory logbook** to record the work you do. Laboratory logbooks will be marked twice during the semester by the supervisor and returned in time for the next session. *An attendance register will be taken in the workshop*.

5.3 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 unit, you will need to exert good self discipline to manage your private study time effectively particularly as you will be studying other level 1 units 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 units 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 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 units 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 teaching timetable §6, to find out the objectives for the topic and read the short description of the lecture.
- 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 print outs 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 on what has been achieved. Read and act on any feedback provided by the instructor.

5.4 Employability

In this unit you will continue to develop skills relating to logbook upkeep, in particular the techniques for presenting comparative results and observations from practical measurements. You will become familiar with some basic measuring instruments for a.c. quantities and use oscilloscopes for inspecting a.c. waveforms and become acquainted with the notions/terminology of peak and rms values and zero-crossings etc. You will learnt how to connect simple circuits given a circuit schematic diagram.

6.0 THE PROGRAMME OF TEACHING, LEARNING AND ASSESSMENT

There are two one hour lectures each week, divided into electrical and circuits part, delivered by Mr Ponugubati and Mr Howson respectively.

Study week	Topic in lecture slot
	Electrical part – Mr Ponugubati
1	**Introduction.** **Learning outcomes:** To know how the unit is organised, how to use the study guide, plan your weekly time, use the workshop manual and the course notes.
1-3	**Magnetic fields and circuits** *Magnetic fields and quantities. Magnetic equivalent circuit. Calculations for simple shapes* The behaviour of an electrical circuit can be completely described in terms of the voltage and current at various points in the circuit. In contrast magnetic fields are distributed through a region and must be defined in terms of two or three dimensions. However when ferromagnetic material is introduced, magnetic circuits can often be treated in a similar manner to electrical circuits and use similar concepts such as lumped components and equivalent circuits. Learning outcomes. **You will:** 1. understand how magnetic properties of materials are used in electromagnetic devices. 2. be able to perform simple steady state calculations on simple magnetic core shapes using the concept of the magnetic equivalent circuit.
4-7	**A.C. Networks – single-phase** *Steady state single phase circuits and phasors, impedance* *Power relationships in single phase circuits* An understanding of ac. steady state circuit operation is so fundamental and an important building block for the study of transient operation and the operation of many devices used in industry. You will see why it is advantageous to use *phasors* for ac. circuit analysis despite the requirement for the seemingly abstract complex number representation. Ac. power calculations will be covered and you will learn about the concept of *real and quadrature power*. Learning outcomes. **You will:** 1. be able to apply the techniques of complex number and phasor analysis to steady state a.c. circuits containing resistance, reactance and sinusoidal sources. 2. be able to find the impedances, voltages and currents and the complex power flows in single phase balanced circuits.
8-9	**A.C. Networks – three-phase** *Steady state 3-phase circuits and phasors, impedance. Power relationships.* Methods will be introduced to handle *balanced* three phase circuits which basically treat the circuit as an equivalent single phase system. **Learning outcomes:** You will be able to find the impedances, voltages and currents and the complex power flows in balanced three phase circuits.
10-12	**Magnetically coupled circuits and transformers** *Self inductance, mutual inductance. Coupling factor. Energy storage in magnetic fields.* *Principles of construction, approximate equivalent circuit. Testing, efficiency.* When there is a change in the magnetic field in the vicinity of a conductor then the conductor will have an emf. induced in it - this is Faradays law and leads to the concept of *inductance* and the link between electric and magnetic circuits. Magnetically coupled circuits will also be studied leading to the concept of mutual inductance between coils and coupling factor relationships. Ferromagnetic circuits can also be used to couple two or more electrical circuits so that electrical energy may be transferred between them - the principle of the transformer. Transformer construction and use will also be covered and equivalent circuits developed which you will use to predict performance under ac. steady state conditions. You will also find out why a transformer is usually very efficient, how to calculate its maximum efficiency and what affects the rating of transformers. Learning outcomes: **You should be able to:** 1. understand the simple fundamental laws relating electrical and magnetic circuits. 2. perform self and mutual inductance calculations on simple coil configurations. 3. understand the action, properties and use of transformers in electrical circuits and perform calculations using the simplified equivalent circuit.
13	**Revision** **Learning outcome:** To develop self-confidence in solving problems and tackle any troubles arising from your general revision.

Study week	Topic in lecture slot
	Circuits part – Mr Howson

1	**Introduction to Circuit theory, Energy, Power** and the 3 basic assumptions that enable this theory to be applied. Definitions of voltage and current; the mathematical relationship between voltage and the energy required to transfer charge; the mathematical relationship between current and the rate of flow of charge; and the mathematical relationship between power and the rate of energy delivered or absorbed by a circuit element. **Learning Outcomes:** 1. You will know the three basic assumptions under which circuit theory is valid (electrical effects happen instantaneously throughout a system; net charge on every component in the system is zero; there is no magnetic coupling between components in the system). 2. You will know that voltage is an electric force created by the separation of electrical charges. 3. You will know that current is an electric field caused by the motion of electric charges. 4. You should know what the following mathematical relations represent: $$v = \frac{dw}{dq}, i = \frac{dq}{dt}, p = \frac{dw}{dt} = \left(\frac{dw}{dq}\right)\left(\frac{dq}{dt}\right) = vi$$ Where *v* is the voltage in volts (V), *w* is the energy in joules (J), *i* is the current in amperes (A), q is the charge in coulombs (C), t is time in seconds (s), p is the power in watts (W).
2	**The starting point for circuit analysis.** Reference directions for voltages and currents in a circuit, the Passive Sign Convention, and the rules for interpreting the algebraic sign of power. The basic topology of networks/circuits is introduced. Independent and controlled sources **Learning Outcomes:** 1. You will know what a circuit diagram is and appreciate the following terms: element, conductor, node, mesh, loop and the voltage/current behaviour of independent sources. 2. You should be able to assign any arbitrary reference directions to the voltage across and the current flowing through a two-terminal circuit component and use these reference directions to systematically predict the power absorbed/delivered in the component from actual voltage/current measurements. 3. You should also know how to apply the Passive sign convention to assign positive/negative signs to mathematical relations between voltage and current.
3	**The Resistor** This lecture looks at the voltage and current relationships in single source series and parallel networks. **Learning outcomes.** You should know: 1. How electrical power flow in a resistor is related to the resistor current and voltage. 2. How to solve resistor circuits quickly and easily where all elements are in series or in parallel. 3. The current and voltage divider rules. 4. What it means to say two elements are electrically equivalent. 5. Equivalent resistive circuits.
4	**Kirchhoff's Current Law and Voltage Law** Current is introduced as a flow signal through a conductor. Kirchhoff's current law describes the behaviour of the current when current carrying conductors meet at a junction. Voltage is introduced as a potential difference that requires the concept of a reference point. The voltages around a closed path must obey Kirchhoff's voltage law. **Learning Outcomes.** You should know that: 1. Kirchhoff's current law (KCL) basically states that the total current entering a junction (circuit node) must equal the total current that leaves it at any instant of time. 2. Kirchhoff's voltage law (KVL) basically states that the total voltage applied to a closed path (loop) in a circuit must equal to the total voltage drops in that path. 3. You should be able to apply the two laws together to set up equations that can be solved to find any unknown voltage or current in a circuit. Contd…
5/6	**Source-Resistor circuit techniques; Kirchhoff's Voltage and Current Laws**. Step by step methods for translating circuit problems into systems of simultaneous equations no matter how complicated the circuit. The techniques although more widely applicable are initially restricted to source resistor circuits. Application of KCL and KVL to two and three mesh circuits containing more than one signal source. **Learning outcome:** You should develop confidence in using KCL and KVL.
7/8	**The Node Voltage method** The systematic application of KCL to (N-1) nodes of a current source-resistor circuit. The writing of equation systems in matrix form will be taught. In Week 8 the Node-Voltage analysis of special cases will be covered such as dependent sources with the concept of a Supernode. **Learning outcomes.** You should know how to: 1. Write systematic simultaneous nodal equations 2. Write the equations in matrix form 3. Use Cramers Rule to solve for any desired voltage

9/10	**The Mesh-Current method** The systematic application of KVL to the meshes of a voltage source resistor circuit. In week 10 the application of mesh-current analysis to special cases will be covered such as dependent sources and if a branch contains a current source then by the creation of a supermesh. **Learning outcome:** You should know how to write and solve systematic simultaneous mesh equations
11	**More on Node and Mesh analysis** Dealing with voltage sources in node analysis and current sources in mesh analysis. Loop equations for non-planar networks. **Learning outcome**: You should know how to set up simultaneous equations systematically for any source-resistor circuit based on either node or mesh/loop analysis.
12	**Unit review**

Notes:

a) *You will find 4 coloured pens useful in some of the lectures.*

b) This programme allows lectures to finish in week 12 to give about one week for revision. The laboratory workshop sessions will also finish by week 12

7.0 LEARNING RESOURCES

7.1 Core Materials

The recommended texts for the unit are:

Electrical: Smith, R J & Dorf, R C. *Circuits, Devices and Systems*. (5th ed); Wiley, 1995.

Circuits: Nilsson, J W & Riedel, S A. *Electric Circuits*, Prentice Hall 6th (or higher) Edition, 1996 & 2000.

7.2 In House Support Materials

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

- **Unit Guide (this document!).** This contains details on how the unit is organised and assessed, a weekly teaching timetable, the teaching and learning programme to be followed. One copy given to each person studying the unit.
- **Course Notes (lecture notes).** These contain some parts of the lecture material which will be used in the course. One copy given to each person studying the unit.
- **Workshop Manual.** This contains an introduction and explanation of the organisation of the workshop, introductions to keeping a laboratory log book, and the instructions for the workshop exercises. One copy given to each person studying the unit.

7.3 Blackboard Website

We will be using “Blackboard” (Bb), a web-based Virtual Learning Environment (VLE) to support learning activities on this unit. The VLE contains space to put announcements and course information, downloadable learning materials, assignments, unit guides, discussion boards and chat rooms, email hosting assessment tests and questionnaires.

Students log onto Blackboard using their LSBU Username and LSBU Windows password. Students who have LSBU computer accounts and are enrolled onto

courses/units will automatically be connected to Blackboard sites supporting their areas of study.

Go to the University Blackboard site: http://blackboard.lsbu.ac.uk/ the Blackboard welcome screen loads with an information page (have a look through this on first entry) and login area.

At the login area type in your individual LSBU Username (no spaces) and your LSBU Windows password **(KEEP A NOTE OF THESE).**

Press the <Login> button. You are then enrolled on Bb and the ELF1 site should appear the list of the sites associated with your study area. You may be asked for additional details and be able to change some personal parameters.

Accesses to the LSBU Blackboard login screen can be made directly using:

https://www.lsbu.ac.uk/bb/

After which you log in using your user name and password, and are taken directly to the courses screen.

An electronic copy of this Unit Guide will be found here, also any updated course material. By simple selection of tick boxes there is also scope to send emails between individuals on the unit and to all students who have enrolled on the unit in Blackboard.

7.4 Optional Materials

Edminster, J A. Electric Circuits. (3rd Ed) McGraw-Hill, 1996.

J.D. Irwin & C.H. Wu, Basic Engineering Circuit Analysis, Prentice Hall 6th Ed, '98

R R Pettitt January 2008