Unit 5019: Further Electrical, Electronic and Digital Principles

Unit Code: H/651/0882

Level: 5

Credits: 15

Introduction

Almost every aspect of our lives relies on electrically powered, electronically controlled machines and devices, many of them digital in format. To properly understand how to make the most efficient use of these devices in a safe and economical way, it is vital to have a thorough knowledge of the underlying principles on which they rely.

This unit builds on the preliminary techniques and skills introduced in *Unit 4019: Electrical, Electronic Principles* and *Unit 4020: Digital Principles*.

The emphasis in this unit will be in developing a structured approach to the analysis of AC single-phase and three-phase powered circuitry. This will help students to arrive at the solution in the most efficient way, with the greatest probability of it being correct. In addition, students will be introduced to the expanding use of computers, using specialised software to solve electrical, electronic, and digital circuits. This will allow students to develop the necessary confidence and competence in the four key areas of mathematical techniques, circuit analysis, circuit simulation and laboratory practice.

Successful completion of this unit will enable students to manage increasingly complex problems and prepare them for the challenge of Level 6 academic programmes.

Learning Outcomes

By the end of this unit students will be able to:

LO1 Solve a range of electrical and electronic problems by applying appropriate circuit theorems and mathematical methods

LO2 Apply appropriate methods to analyse and solve three-phase network problems

LO3 Examine analogue and digital circuits using appropriate laboratory and simulation techniques

LO4 Explain the characteristics of non-linear circuits to predict their behaviour under a variety of conditions

Essential Content

LO1 **Solve a range of electrical and electronic problems by applying appropriate circuit theorems and mathematical methods**

Formal steady state circuit analysis:

Determinants, mesh analysis and nodal analysis (and their comparison)

Analysis using ideal sources

Application of fundamental electrical circuit theorems (e.g. complex numbers, reactance, impedance, Kirchhoff's laws, Norton and Thevenin's theorems, superposition)

AC and DC analysis similarities and differences.

AC circuit analysis:

Complex notation, polar and Cartesian coordinates, RLC circuits

Advanced use of phasor diagrams

Power: instantaneous power, power factor, apparent power, the power triangle

AC and DC power analysis similarities and differences

AC and DC power applications examples.

LO2 **Apply appropriate methods to analyse and solve three-phase network problems**

Three-phase theory:

Theorems and theoretical aspects of three-phase networks

Application of trigonometric methods to solution of phasor diagrams

Application of complex numbers to represent quantities in AC circuits

Single-phase representation, and power flow analysis

Solution of balanced three-phase circuits

Analysis and comparison of delta and wye configurations

Complex notation applied to three-phase, unbalanced loads, unconnected neutral point

Real power, reactive power, apparent power, power factor correction, and efficiency for three-phase systems

Power measurements and calculations in AC and three-phase systems

Applications of three-phase systems.

LO3 **Examine analogue and digital circuits using appropriate laboratory and simulation techniques**

ECAD:

Use of computer modelling and simulation techniques to analyse and solve electronic, electrical, and digital circuits, such as filters and amplifiers using operational amplifiers and discrete devices; digital logic circuit elements; and simple combination and sequential circuits

Health and safety policies, procedures and regulations, risk assessment and mitigation, workplace considerations (i.e., devices and operating personnel)

Use of electrical and electronic instrumentation devices (e.g. multimeter, signal generator, power supply, oscilloscope, etc.) to take measurements of various circuits

Input/Output analysis for electronic, electrical, and digital circuits including combinations of systems

DC-AC conversion with example practical applications.

LO4 **Explain the characteristics of non-linear circuits to predict their behaviour under a variety of conditions**

Non-linear circuits:

Characteristics of linear and non-linear circuits (e.g. I-V relationships, component behaviour, hysteresis, memory effects, etc.), mathematical modelling of a number of semiconductor devices, including diodes, bipolar and Field Effect Transistors and how this can be used to predict their 'real' behaviour in practice

Mathematically modelling the behaviour of semiconductor diodes, bipolar transistors, and Field Effect Transistors

Non-linear behaviour of operational amplifiers.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Solve a range of electrical and electronic problems by applying appropriate circuit theorems and mathematical methods		
P1 Solve electrical AC circuit problems by applying the appropriate theorems and methods.	**M1** Analyse behaviour of AC circuits in terms of electrical power and performance.	**D1** Analyse the performance of AC circuits and their application, with justification of the theorems and methods used, including mathematical methods and/or simulation.
LO2 Apply appropriate methods to analyse and solve three-phase network problems		
P2 Apply suitable theories and methods to solve three-phase network problems for a given industry context.	**M2** Analyse how to synthesise three-phase systems in terms of electrical power, efficiency, and performance.	**D2** Critically analyse the performance of three-phase circuits and their application, with justification of the methods used.
LO3 Examine analogue and digital circuits using appropriate laboratory and simulation techniques.		
P3 Examine the performance of analogue and digital circuits by using the appropriate laboratory and simulation techniques.	**M3** Analyse analogue and digital circuits behaviour using the appropriate laboratory and simulation techniques.	**D3** Evaluate the operation of analogue and digital circuits by comparing their predicted behaviour with simulated, theoretical and practical results.
LO4 Explain the characteristics of non-linear circuits to predict their behaviour under a variety of conditions		
P4 Explain the characteristics of non-linear circuits and how their behaviour differs in practice with 'ideal' devices.	**M4** Investigate a variety of non-linear circuits by calculating and/or simulating the effects of non-linear behaviour in a number of differing circuits.	**D4** Evaluate the application of theory, simulation and practical investigation of a number of circuits, using non-linear circuit theory.

Recommended Resources

Note: See HN Global for guidance on additional resources.

Print Resources

Bird J. (2013) *Electrical Circuit Theory and Technology*. Routledge.

Boylestad R.L. (2023) *Introductory Circuit Analysis.* Global Edition. 14th Ed. Pearson.

Boylestad R.L., and Nashelsky L. (2013) *Digital fundamentals: A systems approach*. Pearson.

Fleckenstein J.E. (2020) *Three-Phase Electrical Power*. CRC Press.

Emery R.C. (2020) *Digital Circuits: Logic and Design.* 1st Ed. CRC Press.

Hambley A.R. (2018) *Electrical Engineering: Principles and Applications*. Global Edition. 7th Ed. Pearson.

Hughes E. et al. (2012) *Electrical and Electronic Technology*. Pearson.

Mohindru P. and Mohindru P. (2022) *Electronic Circuit Analysis using LTSpice XVII Simulator: A Practical Guide for Beginners*. 1st Ed. CRC Press.

Rehg J.A. and Sartori G.J. (2005) *Industrial Electronics*. Prentice-Hall.

Robertson C.R. (2008) *Fundamental Electrical and Electronic Principles*. 3rd edition, Newnes.

Wilamowski B.M. and Irwin J.D. (2011) *The Industrial Electronic Handbook: Fundamentals of Industrial Electronics*. CRC Press.

Journals

Note: Example journals listed below provide a broad range of articles related to unit content and those relevant for the qualification. Staff and students are encouraged to explore these journals and any other suitable journals to support the development of academic study skills, and subject specific knowledge and skills as part of unit level delivery.

Advances in Electrical Engineering, Electronics and Energy

Electronic Letters

Electronics World Magazine

Everyday Practical Electronics Magazine

IEEE Transactions on Circuits and Systems

IEEE Transactions on Industrial Electronics

IEEE Transactions on Power Electronics

Industrial Economics Society

Journal of Electrical and Electronic Engineering

New Electronics Digital Magazine

Links

This unit links to the following related units:

Unit 4019: Electrical and Electronic Principles

Unit 4020: Digital Principles.