Unit 4019: Electrical and Electronic Principles

Unit Code: F/651/0737

Level: 4

Credits: 15

Introduction

Electrical engineering is mainly concerned with the movement of energy and power in electrical form, and its generation and consumption. Electronics is mainly concerned with the manipulation of information, which may be acquired, stored, processed or transmitted in electrical form. Both depend on the same set of physical principles, though their applications differ widely. A study of electrical or electronic engineering depends very much on these underlying principles; these form the foundation for any qualification in the field, and are the basis of this unit.

The physical principles themselves build initially from our understanding of the atom, the concept of electrical charge, electric fields, and the behaviour of the electron in different types of material. This understanding is readily applied to electric circuits of different types, and the basic circuit laws and electrical components emerge. Another set of principles is built around semiconductor devices, which become the basis of modern electronics. An introduction to semiconductor theory leads to a survey of the key electronic components, primarily different types of diodes and transistors.

Electronics is very broadly divided into analogue and digital applications. The final section of the unit introduces the fundamentals of these, using simple applications. Thus, under analogue electronics, the amplifier and its characteristics are introduced. Under digital electronics, voltages are applied as logic values, and simple circuits made from logic gates are considered.

On successful completion of this unit students will have a good and wide-ranging grasp of the underlying principles of electrical and electronic circuits and devices, and will be able to proceed with confidence to further study.

Learning Outcomes

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

LO1 Apply an understanding of fundamental electrical quantities to analyse circuits with constant voltages and currents

LO2 Analyse circuits with sinusoidal voltages and currents

LO3 Describe the basis of semiconductor action, and its application to simple electronic devices

LO4 Explain the difference between digital and analogue electronics, describing simple applications of each.

Essential Content

LO1 Apply an understanding of fundamental electrical quantities to analyse circuits with constant voltages and currents

Fundamental electrical quantities and concepts:

Charge, current, electric field, energy in an electrical context, potential, potential difference, resistance, electromotive force, conductors, insulators, and electrical power

Modern applications examples of electrical systems.

Circuit laws:

Voltage sources, Ohm's law, resistors in series and parallel, the potential divider

Kirchhoff's laws, Thevenin's theorem, Norton's theorem, superposition.

Energy and power:

Transfer into the circuit through, for example, battery, solar panel or generator, and out of the circuit as heat or mechanical. Maximum power transfer theorem

Power analysis and test methods.

LO2 Analyse circuits with sinusoidal voltages and currents

Fundamental quantities of periodic waveforms:

Frequency, period, peak value, phase angle, waveforms, the importance of sinusoids.

Mathematical techniques:

Trigonometric representation of a sinusoid. Rotating phasors and the phasor diagram. Complex notation applied to represent magnitude and phase.

Reactive components:

Principles of the inductor and capacitor. Basic equations, emphasising understanding of rates of change (of voltage with capacitor, current with inductor). Current and voltage phase relationships with steady sinusoidal quantities, representation on phasor diagram; Inductor and capacitor applications.

Circuits with sinusoidal sources:

Current and voltage in series and parallel RL, RC, LC and RLC circuits.

Transient and Steady State analysis of RL, RC, LC and RLC circuits

Reactance, impedance, resonance, bandwidth, quality factor

Time and frequency response of filters

Mains voltage single-phase systems. Active power, reactive power, complex Power, root-mean-square power quantities, power factor

Introduction to DC and AC generators/motors, introduction to three phase power systems.

Ideal transformer and rectification:

The ideal transformer, half-wave and full-wave rectification. Use of smoothing capacitor, ripple voltage.

LO3 **Describe the basis of semiconductor action, and its application to simple electronic devices**

Semiconductor material:

Characteristics of semiconductors; impact of doping, p-type and n-type semiconductor materials, the p-n junction in forward and reverse bias.

Simple semiconductor devices:

Characteristics and simple operation of junction diode, Zener diode, light emitting diode, bipolar transistor, Junction Field Effect Transistor (FET) and Metal Oxide Semiconductor FET (MOSFET). The bipolar transistor as switch and amplifier.

Simple semiconductor applications:

Diodes: AC-DC rectification, light emitting diode, voltage regulation

Transistors: switches and signal amplifiers

Modern applications examples of electronic devices.

LO4 **Explain the difference between digital and analogue electronics, describing simple applications of each**

Analogue concepts:

Analogue quantities, examples of electrical representation of, for example, audio, temperature, speed, or acceleration

The voltage amplifier; gain, frequency response, input and output resistance, effect of source and load resistance (with source and amplifier output modelled as Thevenin equivalent)

Introduction to operational amplifiers.

Digital concepts:

Logic circuits implemented with switches or relays

Use of voltages to represent logic 0 and 1, binary counting

Logic Gates (AND, OR, NAND, NOR) to create simple combinational logic functions

Truth Tables.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Apply an understanding of fundamental electrical quantities to analyse circuits with constant voltages and currents		
P1 Apply the principles of circuit theory to simple circuits with constant sources, to explain the operation of that circuit.	**M1** Apply the principles of circuit theory to a range of circuits with constant sources, to explain the operation of that circuit.	**D1** Examine the operation of a range of circuits with constant sources, including power analysis, using relevant circuit theories.
LO2 Analyse circuits with sinusoidal voltages and currents		
P2 Analyse RLC circuits, using the principles of circuit theory with sinusoidal sources.	**M2** Analyse RLC circuits, using the principles of circuit theory and mathematical techniques used with sinusoidal sources.	**D2** Evaluate the operation and behaviour of series and parallel RLC combined circuits, including resonance and using the principles of circuit theory with sinusoidal sources.
LO3 Describe the basis of semiconductor action, and its application to simple electronic devices		
P3 Describe the behaviour of a p-n, pnp, npn junctions in terms of semiconductor behaviour. **P4** Demonstrate the action of a range of semiconductor devices in both analytical and practical settings.	**M3** Analyse the operation of a range of discrete semiconductor devices in terms of simple semiconductor theory.	**D3** Discuss the performance of a range of semiconductor devices in terms of simple semiconductor theory and their applications.
LO4 Explain the difference between digital and analogue electronics, describing simple applications of each		
P5 Explain the difference between digital and analogue electronics. **P6** Explain the operation and characteristics of amplifiers in analytical and practical settings. **P7** Examine the operation of logic circuits in analytical and practical settings.	**M4** Critique the benefits and drawbacks of using analogue and digital electronic devices using examples.	**D4** Evaluate the use of analogue and digital devices and circuits in specific applications.

Recommended Resources

Note: See HN Global for guidance on additional resources.

Print Resources

Boylestad R.L., Nashelsky, L. (2013) *Electronic devices and circuit theory*. Pearson.

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

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

Hughes E., Hiley, J., Brown, K. and McKenzie-Smith, I. (2016) *Electrical and Electronic Technology*. 12th Ed. Pearson.

Floyd T.L. (2017) *Digital fundamentals.* 11th Ed. Global Edition. Pearson.

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

Singh K. (2011) *Engineering Mathematics through Applications*. 2nd Ed. Palgrave.

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 and 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 4020: Digital Principles

Unit 4022: Electronic Circuits and Devices

Unit 5019: Further Electrical, Electronic and Digital Principles.

