

Unit 19: Electrical and Electronic Principles

Unit code	M/615/1493
Unit level	4
Credit value	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:

1. Apply an understanding of fundamental electrical quantities to evaluate circuits with constant voltages and currents.
2. Evaluate circuits with sinusoidal voltages and currents.
3. Describe the basis of semiconductor action, and its application to simple electronic devices.
4. 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 and insulators

Circuit laws:

Voltage sources, Ohm's law, resistors in series and parallel, the potential divider
Kirchhoff's and Thevenin's laws; 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

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

Circuits with sinusoidal sources:

Current and voltage in series and parallel RL, RC and RLC circuits. Frequency response and resonance

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

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

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)

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
L01 Apply an understanding of fundamental electrical quantities to analyse circuits with constant voltages and currents		D1 Evaluate the operation of a range of circuits with constant sources, using relevant circuit theories.
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	
L02 Analyse circuits with sinusoidal voltages and currents		D2 Analyse the operation and behaviour of series and parallel RLC circuits, including resonance and using the principles of circuit theory with sinusoidal sources.
P2 Analyse series RLC circuits, using the principles of circuit theory with sinusoidal sources.	M2 Analyse series and parallel RLC circuits, using the principles of circuit theory with sinusoidal sources.	
L03 Describe the basis of semiconductor action, and its application to simple electronic devices		D3 Analyse the performance of a range of discrete semiconductor devices in terms of simple semiconductor theory, and suggest applications for each.
P3 Describe the behaviour of a p-n junction in terms of semiconductor behaviour P4 Demonstrate the action of a range of semiconductor devices	M3 Explain the operation of a range of discrete semiconductor devices in terms of simple semiconductor theory	

Pass	Merit	Distinction
LO4 Explain the difference between digital and analogue electronics, describing simple applications of each		D4 Evaluate the use of analogue and digital devices and circuits using examples.
P5 Explain the difference between digital and analogue electronics	M4 Explain the benefits of using analogue and digital electronic devices using examples	
P6 Explain amplifier characteristics		
P7 Explain the operation of a simple circuit made of logic gates		

Recommended Resources

Textbooks

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

HUGHES, E., HILEY, J., BROWN, K. and MCKENZIE-SMITH, I. (2012) *Electrical and Electronic Technology*. Pearson.

SINGH, K. (2011) *Engineering Mathematics through Applications*. Palgrave.

Pearson BTEC Higher Nationals Study Guide (2011) Custom Publishing. Pearson.

Links

This unit links to the following related units:

Unit 20: Digital Principles

Unit 22: Electronic Circuits and Devices

Unit 52: Further Electrical, Electronic and Digital Principles