Unit 5: Electrical and Electronic Principles

Unit code: R/601/1453

QCF level: 5

Credit value: 15

Aim

This unit provides an understanding of electrical and electronic principles used in a range of engineering careers and provides the basis for further study of more specialist areas of electrical/electronic engineering.

Unit abstract

Circuits and their characteristics are fundamental to any study of electrical and electronic engineering and therefore a good understanding is important to any engineer.

The engineer must be able to take complex electrical circuit problems, break them down into acceptable elements and apply techniques to solve or analyse the characteristics. Additionally, fine tuning of the circuits can be performed to obtain required output dynamics.

This unit draws together a logical appreciation of the topic and offers a structured approach to the development of the broad learning required at this level. Learners will begin by investigating circuit theory and the related theorems to develop solutions to electrical networks.

In learning outcome 2 the concept of an attenuator is introduced by considering a symmetrical two-port network and its characteristics. The design and testing of both T and π networks is also covered.

Learning outcome 3 considers the properties of complex waveforms and Fourier analysis is used to evaluate the Fourier coefficients of a complex periodic waveform.

Finally, learning outcome 4 introduces the use of Laplace transforms as a means of solving first order differential equations used to model RL and RC networks, together with the evaluation of circuit responses to a step input in practical situations.

Learning outcomes

On successful completion of this unit a learner will:

1 Be able to apply electrical and electronic circuit theory

2 Be able to apply two-port network models

3 Understand the use of complex waves

4 Be able to apply transients in R-L-C circuits.

Unit content

1 **Be able to apply electrical and electronic circuit theory**

Transformation theorems: energy sources as constant-voltage and constant-current generators; Thévenin's and Norton's theorems; delta-star and star-delta transformation

Circuit theory: maximum power transfer conditions for resistive and complex circuits; mesh and nodal analysis; the principle of superposition

Magnetically coupled circuits: mutual inductance; the use of dot notation; equivalent circuits for transformers including the effects of resistive and reactive features

R-L-C tuned circuits: series and parallel resonant circuits; impedance; phase angle; dynamic resistance; Q-factor; bandwidth; selectivity and resonant frequency; the effects of loading on tuned circuit performance

2 **Be able to apply two-port network models**

Network models: symmetrical two-port network model; characteristic impedance, Z_0; propagation coefficient (expressed in terms of attenuation, α, and phase change ß); input impedance for various load conditions including $Z_L = Z_0$; relationship between the neper and the dB; insertion loss

Symmetrical attenuators: T and π attenuators; the expressions for R_0 and α in terms of component values

3 **Understand the use of complex waves**

Properties: power factor; rms value of complex periodic waveforms

Analyse: Fourier coefficients of a complex periodic voltage waveform eg Fourier series for rectangular, triangular or half-wave rectified waveform, use of a tabular method for determining the Fourier series for a complex periodic waveform; use of a waveform analyser; use of an appropriate software package

4 **Be able to apply transients in R-L-C circuits**

Laplace transforms: definition of the Laplace transform of a function; use of a table of Laplace transforms

Transient analysis: expressions for component and circuit impedance in the s-plane; first order systems must be solved by Laplace (ie RL and RC networks); second order systems could be solved by Laplace or computer-based packages

Circuit responses: over, under, zero and critically damped response following a step input; zero initial conditions being assumed

Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	**Assessment criteria for pass** **The learner can:**
LO1 Be able to apply electrical and electronic circuit theory	1.1 calculate the parameters of AC equivalent circuits using transformation theorems 1.2 apply circuit theory techniques to the solution of AC circuit problems 1.3 analyse the operation of magnetically coupled circuits 1.4 use circuit theory to solve problems relating to series and parallel R-L-C tuned circuits
LO2 Be able to apply two-port network models	2.1 apply two-port network model to the solution of practical problems 2.2 design and test symmetrical attenuators against computer models
LO3 Understand the use of complex waves	3.1 calculate the properties of complex periodic waves 3.2 analyse complex periodic waves
LO4 Be able to apply transients in R-L-C circuits	4.1 use Laplace transforms for the transient analysis of networks 4.2 calculate circuit responses to a step input in practical situations.

Guidance

Links

This unit relies heavily on the use of mathematical analysis to support the underlying theory and practical work. Consequently it is assumed that *Unit 1: Analytical Methods for Engineers* has been taught previously or is being delivered in parallel. It may also be linked with *Unit 2: Engineering Science*.

Essential requirements

Learners will require access to a range of electronic test equipment, eg oscilloscopes, signal generators, etc.

Employer engagement and vocational contexts

Delivery of this unit will benefit from centres establishing strong links with employers willing to contribute to the delivery of teaching, work-based placements and/or detailed case study materials.