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Electrical Circuit Analysis and Design

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Preface

Electrical Circuit Analysis and Design is intended for use with the early years of a first degree course in Electrical, Electronic and Control Engineering, and for Higher National Diploma and Certificate courses in Electrical and Electronic Engineering.

The main prerequisite to its use is a knowledge of the basic concepts of electricity, magnetism and mathematics; an introduction to calculus is more in the nature of a corequisite than a prerequisite.

The book has primarily been written for the student, and it is intended that readers should be able to teach themselves the analytical techniques involved. To this end, many fully worked examples are included in the body of the text, and a large number of unworked problems (with solutions) are included at the end of chapters. Throughout the book, both 'power' and 'electronic' circuit examples and problems have been included.

A 'plus' feature of the book is a chapter on the use of SPICE software (Simulated Program with Integrated Circuit Emphasis) for circuit analysis. Examples in this chapter range from resistive d.c. networks to a.c. solutions and transient analysis, and illustrate the practical advantages of this software, which is pre-eminent in the field of circuit analysis.

When writing the book, I decided that it should be written from a logical teaching viewpoint. That is, as with a conventional course, the more understandable parts of circuit theory are treated first, after which the less easy but, technically, more interesting topics are covered.

Chapter 1 covers d.c. circuits and introduces the concept of basic elements and laws, including Kirchhoff's laws together with simple circuit analysis, and described dependent and independent sources.

In chapter 2, we take a first look at network analysis using mesh, nodal and loop analysis. In undergraduate and some HND courses, the latter usually involves a knowledge of network topology, which is also introduced. Finally, an introduction to the duality between circuits having similar mesh and nodal equations is given.

In order to understand circuit analysis fully, the reader should have a grasp of a number of circuit theorems and this, for d.c. circuits, is provided in chapter 3.

To move on to alternating current theory, the reader needs to understand the basis of circuits containing energy storage elements, this information being provided in chapter 4. Here we deal with capacitors, inductors and mutual inductance. Engineers have devised the 'dot' notation to deal with the latter, and this is fully explained in this chapter.

In chapter 5, we look at some of the many interesting aspects of alternating current theory, including phasors and phasor diagrams, complex impedance and admittance, together with series and parallel combinations of elements and circuits. Also covered are power and power factor, together with complex power. Next, in chapter 6, we apply a range of circuit theorems to a.c. networks.

Power-based electrical engineers have a particular interest in polyphase circuits, and this topic is comprehensively covered in chapter 7. This chapter describes and analyses many aspects of three-phase systems, including power measurement and symmetrical components.

Two-port networks are of great significance to electronics and telecommunications engineers and, in chapter 8, the reader is introduced to y , z , h and transmission parameters, together with the relationship between them.

In chapter 9 we meet the transformer, both 'ideal' and 'linear'. A knowledge of these is vital to both electrical and electronic engineers alike.

In chapter 10, we deal comprehensively with the transient analysis of circuits. A practice in many courses is to deal with this topic using two or sometimes three different techniques, each time covering very similar ground! In this chapter we look, initially, at the process of solving first- and second-order circuits by classical methods. These methods generally have a number of disadvantages, which are overcome by the use of the Laplace transform method; the latter is used throughout the remainder of the chapter.

While the Laplace transform method has the minor drawback that we need to spend a little time looking at the development of Laplace transforms before moving on to circuit analysis, it has the great advantage that the solution of circuits (both without and with initial conditions) becomes relatively straightforward. This chapter covers step function (d.c.) and a.c. analysis of first- and second-order circuits, together with transients in magnetically coupled circuits.

A feature of many electrical and electronic courses is the treatment of the frequency response of circuits, and this is described in chapter 11. Additionally, an introduction to complex frequency and the s -plane is provided and, equally importantly, the transformation of time-domain

impedance into its equivalent s -domain impedance is covered. Frequency response is described in terms of Bode diagrams, and the method of drawing the diagrams is outlined in a straightforward manner for both first- and second-order circuits.

Resonance occurs both in electronic and power circuits, and comprehensive coverage of series and parallel resonance is provided in chapter 12. Additional features in this chapter include frequency scaling, selective resonance and tuned coupled circuits.

In chapter 13 the attention of the reader is directed to harmonics and Fourier analysis. A knowledge of Fourier analysis is vital for all engineers, and the chapter includes such topics as waveform symmetry, line spectra, circuit response and the effect of harmonics in a.c. systems. Also included is a section on harmonic analysis.

In chapter 14 we meet one of the most powerful software packages available for analysis of electrical and electronic circuits, namely SPICE (Simulated Program with Integrated Circuit Emphasis). This software, which is both fast and versatile, is widely available both in full and in educational versions, and can be used to solve almost any electrical problem. The solution of a wide range of problems is included in this chapter.

Chapter 15 is devoted to a number of mathematical ‘tools’ needed by engineers and technicians, namely complex numbers, matrices, determinants and partial fractions.

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