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Transmission Lines for Communications

with CAD programs

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Second Edition

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Preface

Many of the topics covered in this text are relevant for undergraduates studying the basic theory of transmission lines, while the more advanced topics are appropriate for postgraduate students and engineers concerned with communications or digital systems. The development of microcomputers in recent years and their widespread availability now makes it feasible to provide computer programs for the synthesis of transmission line systems and for the study of their performance and of the effects of errors. A range of programs is listed in appendix 3 and these can serve as a basis for a computer-aided learning approach to transmission line matching methods.

The emphasis throughout the book is on fundamental principles, rather than particular components, although individual components are described where they serve to illustrate some underlying principle. The material has been restricted to cover only the propagation of the transverse electromagnetic (TEM) mode in lines and cables, but much of the theory and many of the techniques described can be applied directly to the analogous situations in waveguides. Some of the topics, such as wave propagation, are also relevant for power engineers.

The form of some common types of line and the evaluation of the basic line parameters are discussed in chapter 1. The concepts of characteristic impedance, and transmission and reflection coefficient, are introduced in chapter 2 and applied to wave-propagation problems with the aid of the reflection diagram. The effects of non-linear terminations, such as the input and output impedances of logic circuits, are also discussed. An analysis is given for the cross-talk between coupled lines and this is applied to the directional coupler in chapter 4. These topics should be of particular interest to the digital-circuits engineer concerned with high-speed systems.

The properties of lines for steady-state sinusoidal excitation are described in chapter 3, where standing waves and transformed impedance are introduced. The Smith chart, which can give a useful insight into many high-frequency

problems, is described in detail and is used to illustrate many of the principles outlined in later chapters.

Transmission line measurement techniques in the time domain and in the frequency domain are considered.

The widespread application of fast digital systems and broadband communication systems has led to the more traditional standing-wave measurement systems being replaced by swept-frequency systems of measurement based upon vector network analysers or six-port networks. Microcomputers enable error corrections for these wideband systems to be made quickly and easily and conversion between frequency response and time response can be made using the computer to provide the Fourier transform. These topics are outlined in chapter 4.

The remaining chapters deal mainly with impedance matching systems, ranging from the simple quarter-wavelength transformer to multi-section designs and impedance tapers. Throughout there is considerable emphasis on system bandwidth and the effects of errors in manufacture.

I am grateful to the many students who have inadvertently aided my own understanding of transmission-line theory and to all those involved in the production of this text.

I am particularly indebted to my late friend and colleague Bernard Salvage who read much of the text for the first edition and made constructive criticism of it.

C. W. Davidson