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Preface

Interconnects have achieved a prominent position in determining the performance of high-speed digital, RF and microwave circuits. In digital circuits, interconnect delay exceeds that of individual gates and is the primary determinant of clock speed. In RF and microwave circuits, interconnects and passive elements defined using them are critical circuit components.

This design text is both a sequel and an update to the original well-received first and second editions. The expanded text provides foundations for the accurate design of microstrip components and of circuits applicable to microwave, millimetre-wave and high-speed digital sub-systems.

The text is primarily intended for design engineers and research and development specialists who are active in these areas. It has been our attempt to show the commonalities in the design of interconnects in high-speed digital, RF and microwave applications. This is done by showing the common principles of signal transmission. It is also likely to prove useful to instructors and students in advanced undergraduate and graduate electronics and computer engineering courses.

The direction is strongly toward explaining the fundamentals of operation, and towards useful design formulas and approaches — a repeat coverage of well-documented analyses of microstrip structures has been considered unnecessary and out of place here, but is fully cited.

The work is partly based on research and teaching extending over two decades. Microwave and interconnect courses were presented at La Trobe University (Melbourne, Australia), the University of Bradford (Great Britain), North Carolina State University (Raleigh, North Carolina, U.S.A.), and the University of Leeds (Great Britain). The work is also based on short courses on the signal integrity of and interconnect design for high-speed digital circuits. The majority of the research forming the basis of important sections of this book was undertaken at North Carolina State University and at the Royal Military College of Science (Shrivenham, England).

The text is organized into eleven chapters, leading from the physical principles of signal transmission on interconnects, through the fundamental aspects of interconnect and microstrip design, on to circuit applications in RF, microwave, millimetre-wave and high-speed digital circuits. Additional material, including colour figures, are available at the website for this book http://www.wiley.co.uk/commstech.edwards.html or http://www4.ncsu.edu/ mbs/foundations.html.

The design of high-speed interconnects for digital circuits and of RF and microwave transmission lines has significant common elements, but also significant differences. There are common underlying physical principles, and throughout the text this is stressed. The successful design of the highest performance digital interconnects, for example a clock distribution net, requires considerable transmission line knowledge.
Generally, in treatments in papers and chapters of relevant books ‘just enough’ transmission line theory and technology is presented. Not all of the options are covered. Our approach has been to provide the digital interconnect designer with a comprehensive treatment beginning with physical principles in Chapter 1, as well as more pragmatic approaches in Chapter 2, answering such questions as ‘when are inductive effects important?’ However, the interconnect treatment provides the digital designer with the tools for interconnect design now and in the future. The final chapter considers a number of clock distribution designs and, drawing from the material presented throughout the book, illustrates the importance of transmission line knowledge in the design of the highest performance interconnect. In contrast to how this material is often presented to digital designers, we contend that providing just enough knowledge is not enough to develop advanced and competitive interconnect designs.

This book provides a solid basis for RF, microwave and millimetre-wave design. The material enables the designer to make technology choices, and provides insight that supports the early stages of design. The many examples in the book show how these technology choices are made.

A basic review of interconnects and of TEM-mode transmission line theory is presented in Chapter 1. This is intended to provide the fundamentals for concepts and expressions used in many later chapters. Chapter 2 addresses the unique aspects of interconnects in high-speed digital interconnects. Chapter 3 considers interconnect technology, including interconnect and transmission line structures and the effect of substrate and metallization. This chapter may be used as a source of initial interconnect technology decisions.

Chapters 4 through 8 consider specific transmission line structures and interconnect discontinuities. Considerable insight is provided by using current and charge profiles of the various structures.

The text is also intended to be used in short courses and in graduate level courses. Chapter 9 considers power and current handling capability, transitions between different transmission line structures, and measurement techniques. Design studies are considered in the last two chapters of the book, with Chapter 10 looking at applications of passive interconnects to realize circuit functionality such as filters and lumped element components. The realization of lumped element components is particularly important in analog and RF integrated circuits, and Chapter 11 addresses the use of interconnect design technology in active circuits. For example, in Chapter 11 transmission line principles are used in the development of a digital clock architecture capable of supporting clocking at ten gigahertz or more.

Through these chapters the book presents a unifying foundation for the design of interconnects and microstrips. It then shows application of these lines in a variety of passive and active digital, analog, RF and microwave circuits.

T. C. Edwards and M. B. Steer
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