

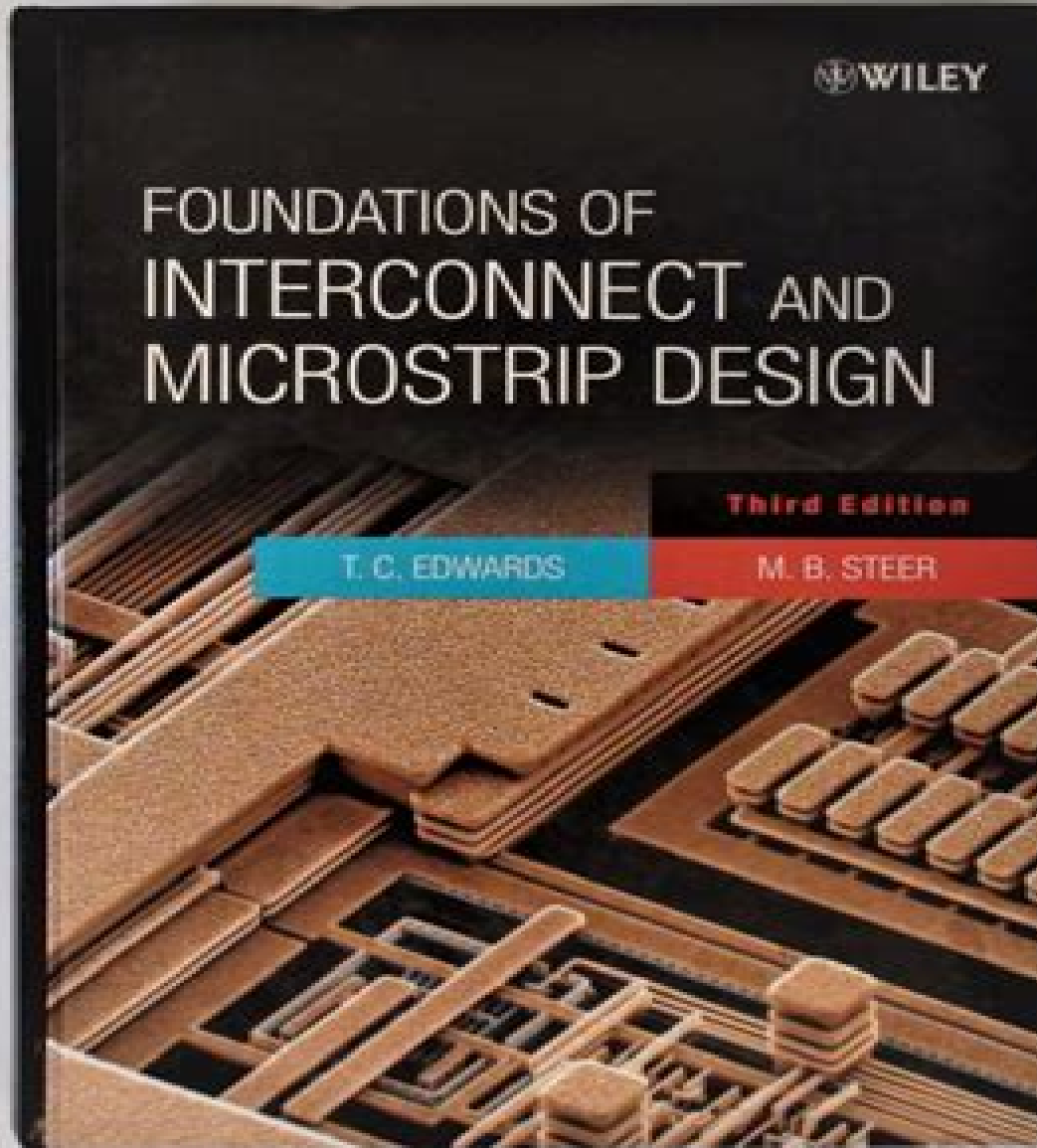
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# FOUNDATIONS OF INTERCONNECT AND MICROSTRIP DESIGN

Third Edition

T. C. EDWARDS

M. B. STEER



# Foundations Of Interconnect And Microstrip Design

**Ian Robertson, Nutapong  
Somjit, Mitchai Chongcheawchamnan**

## **Foundations Of Interconnect And Microstrip Design:**

Foundations of Interconnect and Microstrip Design T. C. Edwards, M. B. Steer, 2000-12-19 Building on the success of the previous two editions *Foundations of Interconnect and Microstrip Design* offers extensive new updated and revised material based upon the latest research In addition to the comprehensive information on designing microstrip circuits there is an entirely new chapter on coplanar waveguide CPW design and substantial new material on designing gigahertz rate digital interconnects both on and off chip Strongly design oriented this third edition provides the reader with a fundamental understanding of this fast expanding field making it a definitive source for professional engineers and researchers and an indispensable reference for senior students in electronic engineering Presents a unified treatment of high speed digital interconnect and microwave transmission line design Provides up to date interconnect design information for gigahertz digital ICs RFICs MICs and MMICs Features design information on dielectric resonators for filters and oscillators Explains design formulas and procedures for numerous types of circuits Discusses techniques suitable for rapid CAE implementation Includes exhaustive appendices covering key concepts transmission line theory Q factor analysis scattering parameter theory and interconnect modelling in circuit simulators Foundations of Interconnect and Microstrip Design Edwards, 2003-05-20

**Foundations for Microstrip Circuit Design** Terry C. Edwards, Michael B. Steer, 2016-02-01 Building on the success of the previous three editions *Foundations for Microstrip Circuit Design* offers extensive new updated and revised material based upon the latest research Strongly design oriented this fourth edition provides the reader with a fundamental understanding of this fast expanding field making it a definitive source for professional engineers and researchers and an indispensable reference for senior students in electronic engineering Topics new to this edition microwave substrates multilayer transmission line structures modern EM tools and techniques microstrip and planar transmission line design transmission line theory substrates for planar transmission lines Vias wirebonds 3D integrated interposer structures computer aided design microstrip and power dependent effects circuit models microwave network analysis microstrip passive elements and slotline design fundamentals *RF and Microwave Circuit Design* Charles E. Free, Colin S. Aitchison, 2021-09-14 *RF and Microwave Circuit Design* Provides up to date coverage of the fundamentals of high frequency microwave technology written by two leading voices in the field *RF and Microwave Circuit Design Theory and Applications* is an authoritative highly practical introduction to basic RF and microwave circuits With an emphasis on real world examples the text explains how distributed circuits using microstrip and other planar transmission lines can be designed and fabricated for use in modern high frequency passive and active circuits and sub systems The authors provide clear and accurate guidance on each essential aspect of circuit design from the theory of transmission lines to the passive and active circuits that form the basis of modern high frequency circuits and sub systems Assuming a basic grasp of electronic concepts the book is organized around first principles and includes an extensive set of worked examples to guide student readers with no

prior grounding in the subject of high frequency microwave technology Throughout the text detailed coverage of practical design using distributed circuits demonstrates the influence of modern fabrication processes Filling a significant gap in literature by addressing RF and microwave circuit design with a central theme of planar distributed circuits this textbook Provides comprehensive discussion of the foundational concepts of RF and microwave transmission lines introduced through an exploration of wave propagation along a typical transmission line Describes fabrication processes for RF and microwave circuits including etched thick film and thin film RF circuits Covers the Smith Chart and its application in circuit design S parameters Mason's non touching loop rule transducer power gain and stability Discusses the influence of noise in high frequency circuits and low noise amplifier design Features an introduction to the design of high frequency planar antennas Contains supporting chapters on fabrication circuit parameters and measurements Includes access to a companion website with PowerPoint slides for instructors as well as supplementary resources Perfect for senior undergraduate students and first year graduate students in electrical engineering courses RF and Microwave Circuit Design Theory and Applications will also earn a place in the libraries of RF and microwave professionals looking for a useful reference to refresh their understanding of fundamental concepts in the field

**The RF and Microwave Handbook** Mike Golio, 2000-12-20 The recent shift in focus from defense and government work to commercial wireless efforts has caused the job of the typical microwave engineer to change dramatically The modern microwave and RF engineer is expected to know customer expectations market trends manufacturing technologies and factory models to a degree that is unprecedented in the

**Design Of Cmos Rf Integrated Circuits And Systems** Kiat Seng Yeo, Manh Anh Do, Chirn Chye Boon, 2010-03-24 This book provides the most comprehensive and in depth coverage of the latest circuit design developments in RF CMOS technology It is a practical and cutting edge guide packed with proven circuit techniques and innovative design methodologies for solving challenging problems associated with RF integrated circuits and systems This invaluable resource features a collection of the finest design practices that may soon drive the system on chip revolution Using this book's state of the art design techniques one can apply existing technologies in novel ways and to create new circuit designs for the future

**RF and Microwave Passive and Active Technologies** Mike Golio, Janet Golio, 2018-10-03 In the high frequency world the passive technologies required to realize RF and microwave functionality present distinctive challenges SAW filters dielectric resonators MEMS and waveguide do not have counterparts in the low frequency or digital environment Even when conventional lumped components can be used in high frequency applications their behavior does not resemble that observed at lower frequencies RF and Microwave Passive and Active Technologies provides detailed information about a wide range of component technologies used in modern RF and microwave systems Updated chapters include new material on such technologies as MEMS device packaging surface acoustic wave SAW filters bipolar junction and heterojunction transistors and high mobility electron transistors HMETs The book also features a completely rewritten section on wide bandgap transistors

*Microwave and Millimetre-Wave Design*

*for Wireless Communications* Ian Robertson, Nutapong Somjit, Mitchai Chongcheawchamnan, 2016-06-20 This book describes a full range of contemporary techniques for the design of transmitters and receivers for communications systems operating in the range from 1 through to 300 GHz In this frequency range there is a wide range of technologies that need to be employed with silicon ICs at the core but compared with other electronics systems a much greater use of more specialist devices and components for high performance for example high Q factor low loss and good power efficiency Many text books do of course cover these topics but what makes this book timely is the rapid adoption of millimetre waves frequencies from 30 to 300 GHz for a wide range of consumer applications such as wireless high definition TV 5G Gigabit mobile internet systems and automotive radars It has taken many years to develop low cost technologies for suitable transmitters and receivers so previously these frequencies have been employed only in expensive military and space applications The book will cover these modern technologies with the follow topics covered transmitters and receivers lumped element filters transmission lines and S parameters RF MEMS RFICs and MMICs and many others In addition the book includes extensive line diagrams to illustrate circuit diagrams and block diagrams of systems including diagrams and photographs showing how circuits are implemented practically Furthermore case studies are also included to explain the salient features of a range of important wireless communications systems The book is accompanied with suitable design examples and exercises based on the Advanced Design System the industry leading CAD tool for wireless design More importantly the authors have been working with Keysight Technologies on a learning teaching initiative which is designed to promote access to industry standard EDA tools such as ADS Through its University Educational Support Program Keysight offers students the opportunity to request a student license backed up with extensive classroom materials and support resources This culminates with students having the chance to demonstrate their RF MW design and measurement expertise through the Keysight RF Microwave Industry Ready Student Certification Program [www.keysight.com/find/eesof/university](http://www.keysight.com/find/eesof/university) [www.keysight.com/find/eesof/student/certification](http://www.keysight.com/find/eesof/student/certification)

*Compact Models and Measurement Techniques for High-Speed Interconnects* Rohit Sharma, Tapas Chakravarty, 2012-02-17 Compact Models and Measurement Techniques for High Speed Interconnects provides detailed analysis of issues related to high speed interconnects from the perspective of modeling approaches and measurement techniques Particular focus is laid on the unified approach variational method combined with the transverse transmission line technique to develop efficient compact models for planar interconnects This book will give a qualitative summary of the various reported modeling techniques and approaches and will help researchers and graduate students with deeper insights into interconnect models in particular and interconnect in general Time domain and frequency domain measurement techniques and simulation methodology are also explained in this book

*Microwave and RF Semiconductor Control Device Modeling* Robert H. Caverly, 2016-02-01 This comprehensive new resource presents a detailed look at the modeling and simulation of microwave semiconductor control devices and circuits Fundamental PIN MOSFET and MESFET

nonlinear device modeling are discussed including the analysis of transient and harmonic behavior. Considering various control circuit topologies, the book analyzes a wide range of models from simple approximations to sophisticated analytical approaches. Readers find clear examples that provide guidance in how to use specific modeling techniques for their challenging projects in the field. Numerous illustrations help practitioners better understand important device and circuit behavior, revealing the relationship between key parameters and results. This authoritative volume covers basic and complex mathematical models for the most common semiconductor control elements used in today's microwave and RF circuits and systems.

**Symmetry Properties in Transmission Lines Loaded with Electrically Small Resonators** Jordi Naqui, 2015-10-16. This book discusses the analysis, circuit modeling, and applications of transmission lines loaded with electrically small resonators, mostly resonators inspired by metamaterials, focusing on the study of the symmetry-related electromagnetic properties of these loaded lines. It shows that the stopband functionality, resonance, and that these lines exhibit can be controlled by the relative orientation between the line and the resonator, which determines their mutual coupling. Such resonance controllability, closely related to symmetry, is essential for the design of several microwave components such as common mode suppressed differential lines, novel microwave sensors based on symmetry disruption, and spectral signature radio frequency barcodes. Other interesting aspects such as stopband bandwidth enhancement due to inter-resonator coupling and related to complex modes and magnetoelectric coupling between the transmission lines and split ring resonators are also included in the book.

**Solid State Circuits Technologies** Jacobus Swart, 2010-01-01. The evolution of solid state circuit technology has a long history within a relatively short period of time. This technology has led to the modern information society that connects us and tools a large market and many types of products and applications. The solid state circuit technology continuously evolves via breakthroughs and improvements every year. This book is devoted to review and present novel approaches for some of the main issues involved in this exciting and vigorous technology. The book is composed of 22 chapters written by authors coming from 30 different institutions located in 12 different countries throughout the Americas, Asia, and Europe. Thus, reflecting the wide international contribution to the book. The broad range of subjects presented in the book offers a general overview of the main issues in modern solid state circuit technology. Furthermore, the book offers an in-depth analysis on specific subjects for specialists. We believe the book is of great scientific and educational value for many readers. I am profoundly indebted to the support provided by all of those involved in the work. First and foremost, I would like to acknowledge and thank the authors who worked hard and generously agreed to share their results and knowledge. Second, I would like to express my gratitude to the Intech team that invited me to edit the book and give me their full support and a fruitful experience while working together to combine this book.

**Integrated Microwave Front-ends with Avionics Applications** Leo G. Maloratsky, 2012. This highly practical resource offers you an in-depth understanding of microwave front-end integration and how it is applied in the avionics field. You find detailed guidance on

circuit integration including coverage of component miniaturization hybrid and monolithic integrated circuits and 3D design The book addresses system integration with discussions on the combination of different avionic systems single antenna design top bottom front end combination and integration of passive and active antenna modules This first of its kind volume features unique material on novel structures of avionics front end novel transmission lines elements and devices as well as new strategies for microwave front end design Supported with nearly 200 illustrations and more than 160 equations this book is a valuable professional reference and also serves well as a postgraduate textbook

Reliable RF Power Amplifier Design Based on a Partitioning Design Approach Rui Ma, 2010 Front cover Titelseite Impressum Acknowledgments Contents List of Abbreviations and Acronyms Abstract Zusammenfassung Chapter 1 Introduction 1 1 Principle of the Partitioning Design Approach 1 2 Dissertation Organization Chapter 2 Investigation of Planar Interconnection 2 1 Active Chip Device Interconnection 2 1 1 Die Attach 2 1 2 Wire Bonding Pad To Microstrip 2 2 Microstrip to Microstrip Interconnection 2 2 1 Soldering 2 2 2 Multi Wire Bonding 2 2 3 Copper Ribbon 2 2 4 Silver Painting Chapter 3 Analysis and Modeling of Passive SMD Components 3 1 SMD Resistor 3 2 SMD Capacitor 3 3 SMD Inductor Chapter 4 Modeling of AlGaAs GaAs HEMT Chip Device 4 1 AlGaAs GaAs HEMT Chip 4 2 Modeling Approach Overview 4 3 Small Signal Modeling 4 3 1 Extrinsic Parameter Extraction 4 3 2 Intrinsic Parameter Extraction 4 4 Large Signal Modeling 4 4 1 Gate Current and Charge Models 4 4 2 Drain Current Model 4 4 3 Model Verification Chapter 5 Demonstrator Design of a Class AB Power Amplifier Following 5 1 Micro Packaged Device Characterization 5 1 1 Small Signal Performance 5 1 2 Large Signal Performance 5 2 Bias Network Design 5 2 1 Drain Bias Network 5 2 2 Gate Bias Network 5 3 Matching Network Design 5 3 1 Matching Impedance Determination 5 4 Power Amplifier Performance Evaluation 5 4 1 Small Signal Performance 5 4 2 Large Signal Performance Chapter 6 Conclusions and Outlook Appendix Appendix A THLR In Fixture Calibration Appendix B Precise Determination of Substrate Permittivity Appendix C Schematic Circuit of the Designed Power Amplifier Demonstrator Appendix D Power Amplifier Design Following the Conventional Design Approach References Back cover

*Partitioning Design Approach for the Reliable Design of Highly Efficient RF Power Amplifiers* Roshanak Lehna, 2017-11-13 The modern wireless communication systems require modulated signals with wide modulation bandwidth This in turns requires signals with very high dynamic range and peak to average power ratio PAPR This means that the amplifier in the base station has to work at a power back off as large as the dynamic range of the signal so that the amplifier has a high linearity in this region For the standard single stage amplifiers this large power back off reduces the efficiency dramatically In this work a three way Doherty power amplifier DPA aiming at high power efficiency within a dynamic range of 9.5 dB is designed and fabricated using partitioning design approach The partitioning design approach decomposes a complex design task into small sized well controllable and verifiable subcircuits This advanced straight forward method has shown very promising results Using this design approach a three way DPA has been designed to demonstrate the advantages of this reliable design technique as well Based on the

design of a single stage power amplifier and proposing a novel output power combiner a 6 W three way DPA has been designed which allows the mandatory load modulation principle in three way DPA structures to be realized with simpler elements whereas the design of a standard Doherty combiner would have been very challenging and not practical due to the extremely small value of its characteristic line impedance The proposed combiner is calculated for a three way DPA with 2 mm AlGa<sub>N</sub> Ga<sub>N</sub> HEMTs The simulation result shows a very good load modulation for the amplifier which confirms the theoretical expectation for a three way DPA The efficiency of the designed 6 W three way DPA at large back off shows very promising values compared to recently reported amplifiers The measured IMD3 products confirm the good linearity of the amplifier as well Accordingly the proposed power combiner and the design strategy are recommended to be used as the preferred option for designing three way DPA structures with very high output power

**High-speed Signal Propagation** Howard W. Johnson, Martin Graham, 2003 This advanced level reference presents a complete and unified theory of signal propagation for all metallic media from cables to pcb traces to chips It includes numerous examples pictures tables and wide ranging discussion of the high speed properties of transmission lines

**Artificial Transmission Lines for RF and Microwave Applications** Ferran Mart  n, 2015-07-01 This book presents and discusses alternatives to ordinary transmission lines for the design and implementation of advanced RF microwave components in planar technology This book is devoted to the analysis study and applications of artificial transmission lines mostly implemented by means of a host line conveniently modified e g with modulation of transverse dimensions with etched patterns in the metallic layers etc or with reactive loading in order to achieve novel device functionalities superior performance and or reduced size The author begins with an introductory chapter dedicated to the fundamentals of planar transmission lines Chapter 2 is focused on artificial transmission lines based on periodic structures including non uniform transmission lines and reactively loaded lines and provides a comprehensive analysis of the coupled mode theory Chapters 3 and 4 are dedicated to artificial transmission lines inspired by metamaterials or based on metamaterial concepts These chapters include the main practical implementations of such lines and their circuit models and a wide overview of their RF microwave applications including passive and active circuits and antennas Chapter 5 focuses on reconfigurable devices based on tunable artificial lines and on non linear transmission lines The chapter also introduces several materials and components to achieve tuning including diode varactors RF MEMS ferroelectrics and liquid crystals Finally Chapter 6 covers other advanced transmission lines and wave guiding structures such as electroinductive magnetoinductive wave lines common mode suppressed balanced lines lattice network artificial lines and substrate integrated waveguides Artificial Transmission Lines for RF and Microwave Applications provides an in depth analysis and discussion of artificial transmission lines including design guidelines that can be useful to researchers engineers and students

**Applications of Advanced Electromagnetics** Guennadi A. Kouzaev, 2012-10-30 This text directed to the microwave engineers and Master and PhD students is on the use of electromagnetics to the



development and design of advanced integrated components distinguished by their extended field of applications. The results of hundreds of authors scattered in numerous journals and conference proceedings are carefully reviewed and classed. Several chapters are to refresh the knowledge of readers in advanced electromagnetics. New techniques are represented by compact electromagnetic quantum equations which can be used in modeling of microwave quantum integrated circuits of future. In addition, a topological method to the boundary value problem analysis is considered with the results and examples. One extended chapter is for the development and design of integrated components for extended bandwidth applications and the technology and electromagnetic issues of silicon integrated transmission lines, transitions, filters, power dividers, directional couplers etc. are considered. Novel prospective interconnects based on different physical effects are reviewed as well. The ideas of topology is applicable to the electromagnetic signaling and computing when the vector field maps can carry discrete information and this area and the results in topological signaling obtained by different authors are analyzed including the recently designed predicate logic processor operating spatially represented signal units. The book is rich of practical examples, illustrations and references and useful for the specialists working at the edge of contemporary technology and electromagnetics.

Planar Microwave Engineering Thomas H. Lee, 2004-08-30. Modern wireless communications hardware is underpinned by RF and microwave design techniques. This insightful book contains a wealth of circuit layouts, design tips and practical measurement techniques for building and testing practical gigahertz systems. The book covers everything you need to know to design, build and test a high frequency circuit. Microstrip components are discussed including tricks for extracting good performance from cheap materials. Connectors and cables are also described as are discrete passive components, antennas, low noise amplifiers, oscillators and frequency synthesizers. Practical measurement techniques are presented in detail including the use of network analyzers, sampling oscilloscopes, spectrum analyzers and noise figure meters. Throughout the focus is practical and many worked examples and design projects are included. There is also a CD ROM that contains a variety of design and analysis programs. The book is packed with indispensable information for students taking courses on RF or microwave circuits and for practising engineers.

*Handbook of Research on 5G Networks and Advancements in Computing, Electronics, and Electrical Engineering* Nwajana, Augustine O., Ihianle, Isibor Kennedy, 2021-06-25. The advent of the emerging fifth generation 5G networks has changed the paradigm of how computing, electronics and electrical CEE systems are interconnected. CEE devices and systems with the help of the 5G technology can now be seamlessly linked in a way that is rapidly turning the globe into a digital world. Smart cities and internet of things have come to stay but not without some challenges which must be discussed. The *Handbook of Research on 5G Networks and Advancements in Computing, Electronics, and Electrical Engineering* focuses on current technological innovations as the world rapidly heads towards becoming a global smart city. It covers important topics such as power systems, electrical engineering, mobile communications, network security and more. This book examines vast types of technologies and their roles.

in society with a focus on how each works the impacts it has and the future for developing a global smart city This book is ideal for both industrial and academic researchers scientists engineers educators practitioners developers policymakers scholars and students interested in 5G technology and the future of engineering computing and technology in human society

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