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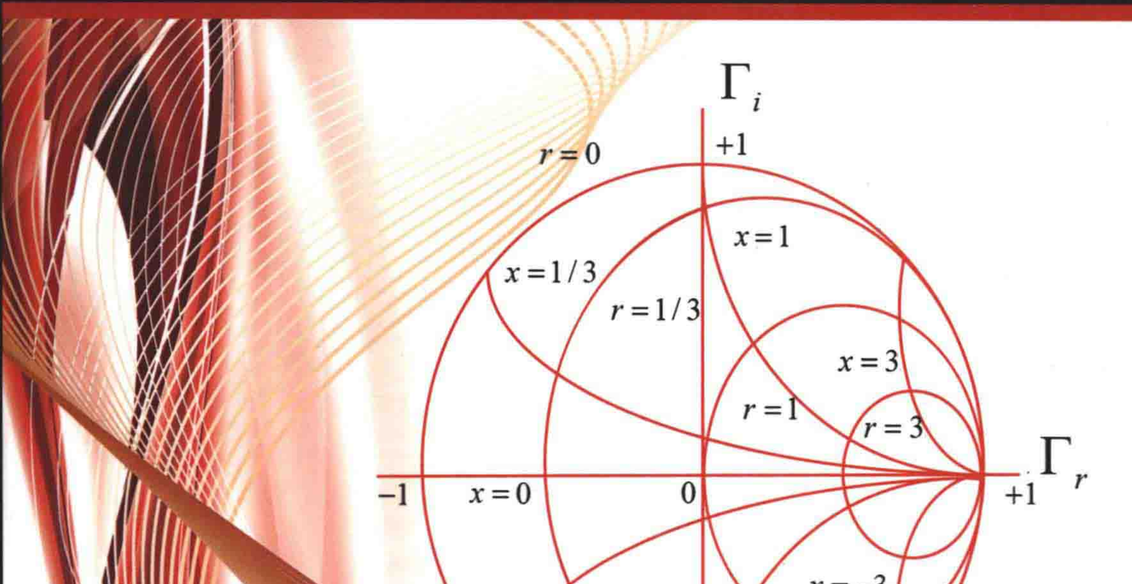
Introduction to RF Power Amplifier Design and Simulation



Abdullah Eroglu

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Dedicated to my sons, Duhan and Enes, and daughter Dilem

Preface

Radio frequency (RF) power amplifiers are used in everyday life for many applications including cellular phones, magnetic resonance imaging, semiconductor wafer processing for chip manufacturing, etc. Therefore, the design and performance of RF amplifiers carry great importance for the proper functionality of these devices. Furthermore, several industrial and military applications require low-profile yet high-powered and efficient power amplifiers. This is a challenging task when several components are needed to be considered in the design of RF power amplifiers to meet the required criteria. As a result, designers are in need of a resource to provide all the essential design components for better-performing, low-profile, high-power, and efficient RF power amplifiers. This book is intended to be the main resource for engineers and students and fill the existing gap in the area of RF power amplifier design by giving a complete guidance with demonstration of the details for the design stages including analytical formulation and simulation. Therefore, in addition to the fact that it can be used as a unique resource for engineers and researchers, this book can also be used as a textbook for RF/microwave engineering students in their senior year at college. Chapter end problems are given to make this option feasible for instructors and students.

Successful realization of RF power amplifiers depends on the transition between each design stage. This book provides practical hints to accomplish the transition between the design stages with illustrations and examples. An analytical formulation to design the amplifier and computer-aided design (CAD) tools to verify the design, have been detailed with a step-by-step design process that makes this book easy to follow. The extensive coverage of the book includes not only an introduction to the design of several amplifier topologies; it also includes the design and simulation of amplifier's surrounding sections and assemblies. This book also focuses on the higher-level design sections and assemblies for RF amplifiers, which make the book unique and essential for the designer to accomplish the amplifier design as per the given specifications.

The scope of each chapter in this book can be summarized as follows. Chapter 1 provides an introduction to RF power amplifier basics and topologies. It also gives a brief overview of intermodulation and elaborates discussion on the difference between linear and nonlinear amplifiers. Chapter 2 gives details on the high-frequency model and transient characteristics of metal–oxide–semiconductor field-effect transistors. In Chapter 3, active device modeling techniques for transistors are detailed. Parasitic extraction methods for active devices are given with application examples. The discussion about network and scattering parameters is also given in this chapter. Resonator and matching networks are critical in amplifier design. The discussion on resonators, matching networks, and tools such as the Smith chart are given in Chapters 4 and 5. Every RF amplifier system has some type of voltage, current, or power-sensing device for control and stability of the amplifier. In Chapter 6, there is an elaborate discussion on power-sensing devices, including four-port directional couplers and new types of reflectometers. RF filter designs for power amplifiers are given in Chapter 7. Several special filter types for amplifiers are discussed, and application examples are presented. In Chapter 8, CAD tools for RF amplifiers are discussed. Unique real-life engineering examples are given. Systematic design techniques using simulation tools are presented and implemented.

Throughout the book, several methods and techniques are presented to show how to blend the theory and practice. In summary, I believe engineers, researchers, and students will greatly benefit from it.

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I thank my wife and children for allowing me to write this book instead of spending time with them. I am deeply indebted to their endless support and love. In addition, my students at Indiana University–Purdue University Fort Wayne will always be an inspiration for me to enhance my research in the area of radio frequency/microwave. As usual, special thanks go to my editor, Nora Konopka, for her understanding when I needed more time.

Author

Abdullah Eroglu earned his MSEE in 1999 and PhD in 2004 in electrical engineering from the Electrical Engineering and Computer Science Department of Syracuse University, Syracuse, NY. From 2000 to 2008, he worked as a radio frequency (RF) senior design engineer at MKS Instruments, where he was involved with the design of RF power amplifiers and systems. He is a recipient of the 2013 IPFW Outstanding Researcher Award, 2012 Indiana University-Purdue University Featured Faculty Award, 2011 Sigma Xi Researcher of the Year Award, 2010 College of Engineering, Technology and Computer Science (ETCS) Excellence in Research Award, and the 2004 Outstanding Graduate Student award from the Electrical Engineering and Computer Science Department of Syracuse University. Since 2014, he is a professor of electrical engineering at the Engineering Department of Indiana University–Purdue University, Fort Wayne, IN. He was a faculty Fellow at the Fusion Energy Division of Oak Ridge National Laboratory during the summer of 2009. His teaching and research interests include RF circuit design, microwave engineering, development of nonreciprocal devices, electromagnetic fields, wave propagation, radiation, and scattering in anisotropic and gyrotropic media. Dr. Eroglu has published over 100 peer-reviewed journal and conference papers. He is also the author of four books. He is a reviewer and on the editorial board of several journals.

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