Preface

In the age where telecommunication has become a standard, almost every portable device has some kind of transmitter and receiver allowing it to connect to a cellular network or available Wi-Fi networks. We are also driving cars that are smarter and equipped with new technologies, such as radars for collision detection. Other types of radars are used in both civilian and military applications. Nowadays, we even receive signals from satellites on our phones from Global Positioning Systems. Radio frequency (RF) identification devices are becoming more and more common and are being used in many applications, from access control to medical applications. In other words, the spectrum around us is full of transmitted signals waiting to be received. Each signal is transmitted by some kind of power amplifier. As a result, all researchers are likely to face the challenge of designing an RF or microwave power amplifier at some stage of their careers.

Design of power amplifiers, however, is not an easy task. Even the great number of power amplifier classes suggests that no single configuration is capable of delivering acceptable performance for several frequency bands and for several applications at once. Thus, the aim of this book is twofold. First, the idea is to provide researchers with enough power amplifier theory to gain sufficient knowledge to choose the best power amplifier stage for the specific application and to understand the most important defining equations and parameters. Second, the design equations to achieve this are very complex, and if they are used to design by hand, they tend to put off researchers and designers. Thus, this book also aims to provide its readers with some ideas on how to simplify the design process by introducing their own software-based procedures or, in other words, by developing their own electronic design automation (EDA). Although MATLAB is used throughout the book to illustrate the concept of EDA (sometimes also termed computer-aided design or CAD), the exact programming language is not important. The accent is on how to identify what is needed as the end result of the power amplifier design, and how to develop custom EDA to reach this result; essentially, this book focuses on the methodology of power amplifier design.

This methodology is conceptualized so that it "trivializes" the approach to power amplifier design by removing the "black magic" approach typically used in the process. This advances research by allowing the readers to shift the focus of research from power amplifiers onto other less-explored components of the system or even on specification refinement. It can be used equally well by researchers focusing on integrated design, or researchers focusing on discrete implementations, which are typically used for high power or higher frequencies. The researchers focusing on the thin line between integrated circuits and discrete implementations, sometimes termed systems-on-package (SOP), are not excluded. Even though different approaches sometimes need to be followed for design in different frequency bands up to and including the Ku-band, similar principles of EDA apply.

This book is organized in two parts. Part I focuses on the main concepts of power amplification, and this part can be used like any reference book. It first presents a review of transmission bands and their implications for transceiver system design. The feasibility of different passive component implementations in each frequency range is investigated, and power amplifiers are placed into the context of the transceiver system. The theory behind transistor operation at large signal levels is included, and various semiconductor fabrication technologies are discussed for full system integration or power transistor fabrication, together with substrates for the implementation of discrete passives and SOP packaging. Other basic aspects of communication theory, such as *S*-parameters, *Y*-parameters, Smith charts, resonance, loaded quality factor (Q-factor), insertion loss impedance transformation, and Fourier theory, are reviewed, which allows for better understanding of power amplifier concepts. This is followed by an in-depth analysis of power amplifier stages. Most of the commonly used power amplification classes (among others A, AB, C, J, D, E, E^{-1}, F, and F^{-1}) are discussed, and the defining equations are included. Passives and their Q-factors are also covered in Part I. This includes resistors, capacitors, integrated inductors, solenoids, toroids, RF chokes, and transformers. Special focus is placed on both discrete and integrated inductor designs, as they tend to exhibit low Q-factors and are therefore paramount to power amplifier design. Micro-electro-mechanical systems are discussed as a promising technology for the design of passives. Lumped and transmission line impedance matching, which is important if the power amplifier is to be connected to the rest of the transceiver system with minimum losses, is also discussed from an analytical, graphical, and EDA perspective, for both real and complex sources and loads.

Part II of the book focuses on developing CAD procedures to aid practical power amplifier design based on the theory reviewed in Part I. Although this book is not intended for computer engineers, it is assumed that every RF researcher has some basic programming skills. The automation and intelligent design ideas for inductor design are presented in this part, which is followed by automation and intelligent design ideas of various on- and off-chip power amplifier classes described in Part I. Previously described design of passive elements and matching are incorporated into this methodology. Real-life power amplifier design examples using the proposed methodology are explored by means of examples, and developed algorithms are illustrated both graphically and in MATLAB. IC layout and fabrication are considered as one alternative for practical implementations, and discrete implementations are considered as a second alternative. A practical aspect of packaging of discrete systems is also explored. Other practical aspects that are not necessarily covered by the EDA flow are also discussed in this part, and a formal procedure for practical power amplifier design is presented. Part II of the book concludes with the ideas for future research.

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