

Preface

The utilization of mm-wave bands for wireless radio systems has gained popularity at a remarkable rate in the last decade. The numerous benefits offered by systems that operate in this frequency range (smaller components, high level of integration, large bandwidths, and substantially improved data rates) have attracted the attention of the research and technical community for some time, while the technology required to implement these systems has continuously matured. A crucial component in wireless radio frequency (RF) and microwave systems is the power amplifier (PA), and this is no different for systems operating in the mm-wave regime. PAs that are able to provide high levels of output power and linearity while being easily integrated with surrounding circuitry are highly sought after, and as such, significant efforts are being focused on pushing the limits on the performance of mm-wave PA. Moreover, the PA has a marked impact on the performance of the system as a whole, and its design involves carefully evaluating the limitations on power consumption (and therefore, battery life), linearity and spectral purity imposed on the system either through the application, or the specification followed. Alternative techniques with regards to PA topologies, passive components and optimizations are constantly being explored in the research community, and this text attempts to consolidate many of the PA developments that are relevant to mm-wave operation.

The goal of this book is to provide readers with an extensive, research-oriented resource on mm-wave PAs. Design issues and limitations commonly encountered are discussed in light of state-of-the-art research, and this approach incidentally forms a large portion of the text. A solid background is provided on mm-wave PA theory as well as technologies that accompany their effective design, with an emphasis on current generation research as well as possible future trends in amplifier design. Emerging and existing applications are discussed in light of the beneficial aspects of transitioning into the mm-wave regime, and the text pays close attention to the challenges relating to the design and manufacturing of such systems. Maturing wireless standards for mm-wave systems, the evolving demand for high-bandwidth communication and increasingly sophisticated fabrication techniques for passive components are some of the major driving forces behind this

transition. The text aims to clearly highlight the nature of implementing PAs in modern mm-wave technology, and explains how these approaches often deviate from established techniques for lower frequency designs (which in this context is below 30 GHz).

This book is intended for readers at or above a graduate level operating in a research environment. While there are numerous introductory sections that discuss basic PA theory, these are often quite brief in order to make way for discussions on more specialized topics and state-of-the-art case studies. These case studies, which are discussed in varying levels of detail throughout the text, should be useful for researchers working in similar fields. With that said, the reader is often referred to a staple of existing textbooks that do cover basic PA theory in extraordinary detail and one would be hard pressed to find a PA designer's book collection that does not include at least one of these. In the context of practical implementation, the techniques and ideas that originate from research efforts in the field (either in academia or industry) are often the first step towards developing standardized solutions. While implementation and manufacturing challenges are mentioned throughout the text, the majority of the content is academically oriented insofar as it focuses on recent developments in the literature.

This book is segmented into two major parts. The first three chapters, which form the introductory section, lay a baseline consisting of PA performance metrics (Chap. 1), commonly encountered mm-wave application areas (Chap. 2), and the current generation of device technology that drives the implementation of mm-wave systems (Chap. 3). Chapter 3 places a strong focus on transistor technologies and their respective figures of merit that determine their usage in mm-wave PAs. In addition, passive technologies such as through-silicon via, on-chip inductors, diodes, and transmission lines are discussed. The second part of this book explores state-of-the-art developments that have been produced primarily by the research community with the principal focus being on PA topologies. Transistor scaling into the nanometer range introduces a myriad of challenges for the designer to overcome, and many PA topologies originally arose in order to deal with these limitations. Additionally, each major amplification technique (linear mode, switching and stacked-device PAs) is divided into two parts for mm-wave CMOS and SiGe HBT technologies.

The second part begins with Chap. 4, discussing the simplest modes of operation that are commonly considered to be linear-mode PAs, and the nuances that relate to linear amplification with nonlinear devices. Moreover, the theoretical basis of reduced conduction angle operation is laid out in this chapter, which is then expanded to express several PA performance metrics in terms of the conduction angle. In contrast to continuous mode operation, Chap. 5 focuses on switching amplifiers which, in contrast to current-source amplifiers, operates the active device as a voltage-controlled switch in order to achieve signal amplification. Chapter 6 focuses on a popular expansion of the switching modes of operation, which involves vertically stacking multiple nonlinear devices, primarily to increase output power. Class-E-like PAs are very well suited for transistor stacking at mm-wave frequencies, and techniques for designing such amplifiers with HBT and

FET devices are covered in detail. Chapter 7 in part consolidates some implementation details discussed in earlier chapters and expands upon these concepts to provide an overview of techniques that are typically employed to improve the performance of mm-wave PAs. Linearity and efficiency are often tightly coupled and, in addition to output power and bandwidth, constitute the PA metrics that often require careful consideration in order to meet the specifications of mm-wave designs. Moreover, new techniques to tackle these issues are constantly being published, and Chap. 7 attempts to cover a broad spectrum of such methods. Chapter 8 takes this concept of performance enhancement to a higher level of abstraction, and discusses how performance issues are addressed at the transmitter architecture level. Several common transmitters are compared in terms of their characteristics and preferred application areas. Furthermore, the emerging concept of PA self-healing is overviewed in Chap. 8.

The authors would like to acknowledge Dr. Riëtte de Lange, Director: Research Productivity & Improvement of Staff Qualifications, Strategic Initiatives & Administration, University of Johannesburg, South Africa for her coordination.

Furthermore, the authors would like to acknowledge the support of technical reviewers as well as language and graphic editors who have all contributed to this process. We value the system of scholarly peer review, and the approach that the same adds towards producing research text that adds to the body of scientific knowledge.

Johannesburg, South Africa

Jaco du Preez
Saurabh Sinha

Millimeter-Wave Power Amplifiers

du Preez, J.; Sinha, S.

2017, XIII, 358 p. 192 illus., Hardcover

ISBN: 978-3-319-62165-4