

Preface

Seven years ago research in the field of mm-wave silicon was virtually non-existent. Few people thought that operation at 60 GHz was even feasible in silicon technology. In the course of seven years the topic has transitioned from an obscure research topic to an exciting buzzword (60 GHz) that has generated much interest from industry and the venture community. To put things in historical perspective, seven years ago most commercial efforts were focused on the 1-10 GHz spectrum for voice and data applications for mobile phones and portable computers. Many people were actively seeking solutions to the “last mile” problem, or a way to deliver high speed data to users in their homes and offices through cable, telephone, or wireless infrastructure. At the same time, the explosive growth of wireless data such as WiFi spurred significant research into and development of new architectures for radio transceivers that could deliver very high data rates over short ranges, particularly for video and personal area networks. This problem can be viewed as the “last meter” or even the “last inch” connection that delivers high bandwidth multimedia content to devices. The growth of MP3 media devices, and now handheld video devices, and the rapid adoption of HDTV and flat screen televisions has created a healthy demand for technology that enables high speed wireless video transmission. For this reason, today we witness a very active interest in mm-wave silicon technology. Other important commercial applications include automotive radar for safety and improved driving experience. But these applications are only the tip of the iceberg.

Research in silicon mm-wave circuits and technology started at universities and research institutions and now continues in the commercial realm. Many of the researchers in the field have contributed to this book to chronicle these efforts. This book is written for practicing RF and analog circuit designers who wish to join this exciting and growing field. The chapters are self-contained and include a short tutorial on important concepts before delving into details. The audience for this book is assumed to be experienced in the field of analog/RF integrated circuits. The focus of each chapter is the key innovations and techniques that enable operation at mm-wave frequencies, which is close to the activity limits of silicon technology. Many of the chapters are focused around several key publications in the field. Rather than republish the original papers, the authors have gone to great lengths to expand the material

and provide more background and breadth than the original technical publication. As such, this book would complement a graduate microwave or mm-wave course based on silicon technology.

The book begins with the fundamental technology scaling and device-level changes that have allowed mm-wave silicon performance. This includes a detailed discussion of the design, modeling, and achievable performance of active and passive components. Next, front-end mm-wave building blocks are covered in detail, including amplifiers and mixers, voltage-controlled oscillators (VCOs) and dividers, and power amplifiers. Complete chipsets operating in the 60 GHz band are also covered. The book culminates in the discussion of phased-array systems capable of beam forming and exploiting spatial diversity for increased throughput or range. Throughout the book we focus on a design methodology and design tools that are optimized for silicon technology. Unique issues related to silicon, such as the lossy silicon substrate, are discussed at each stage of the book. Other important issues include the ever shrinking low supply voltage, which limits the dynamic range and output power capability of the technology.

We hope you find this book useful in your exploration of silicon mm-wave devices, circuits, and systems. There are many unique challenges to working with silicon mm-waves, but there are many rewards to reap from this technology. As the editors, we would like to thank the contributors to this book, including the graduate students and the contributing authors who have worked tirelessly to share their insights with you in this book. We also thank Carl Harris of Springer for making this project happen. To the reader our advice is simple: *think small!*

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60 GHz and Beyond

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