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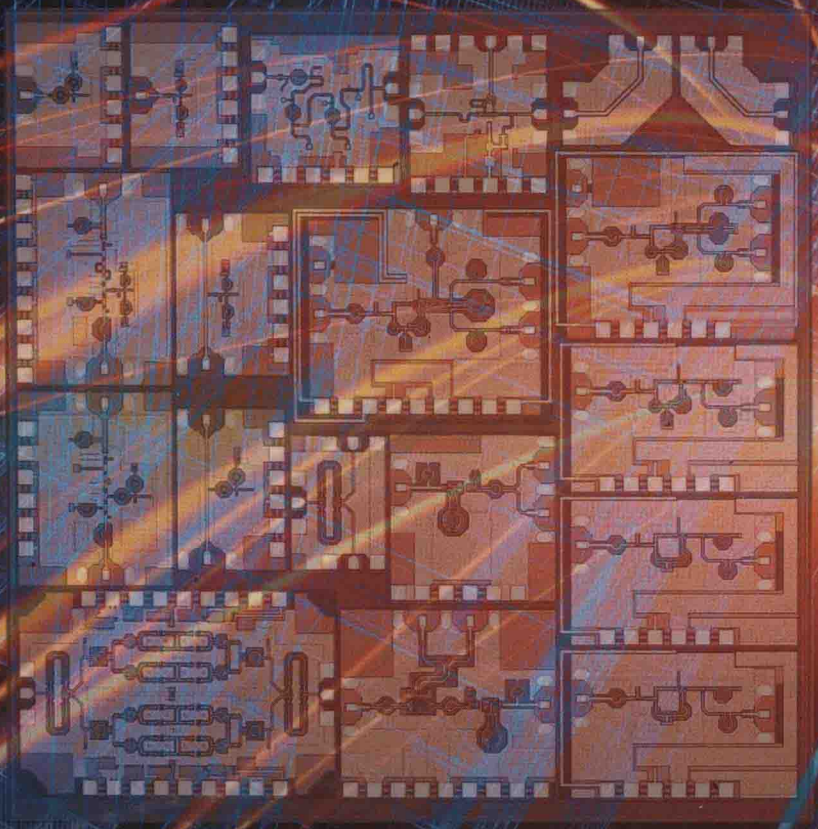

RADIO-FREQUENCY INTEGRATED-CIRCUIT ENGINEERING

CAM NGUYEN, PhD

WILEY

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RADIO-FREQUENCY INTEGRATED-CIRCUIT ENGINEERING

WILEY SERIES IN MICROWAVE AND OPTICAL ENGINEERING

KAI CHANG, Editor
Texas A&M University

A complete list of the titles in this series appears at the end of this volume.

This book is dedicated to my parents (Mr. and Mrs. Nguyễn Xuân Sương), my wife (Trần Ngọc-Diệp), and my children (Christine Nhã-Uyên, Devon, and Andrew Đình-An).

PREFACE

Radio Frequency Integrated Circuits (RFICs) implemented using silicon-based technologies such as complementary metal–oxide–semiconductor (CMOS) and bipolar and complementary metal–oxide–semiconductor (BiCMOS) offer competitive performance with much lower cost and better integration capability than their non-silicon based counterparts. RFIC has become one of the most exciting areas in the radio frequency (RF) domain with contributions and impacts far reaching into the millimeter-wave range and advancing into the sub-millimeter-wave regime. Studies and research for RFIC, particularly those extending into the millimeter-wave region and beyond, across the World have exploded in the past decade and are indeed increasing rapidly.

Several years ago, when my research interests shifted from the then more well-known microwave-integrated circuits and systems to RFICs, I was looking for possible books that address RFIC design, especially from the microwave design point of view, which I consider as absolutely essential for RF operation. As a result, the long journal for this book began and its birth, long overdue, is just now matured.

As RF is moving into very high frequencies now, reaching THz, RF (as it is practiced now) is not different from microwave. RF at present implies frequencies from a few KHz up to hundreds of GHz (not a few GHz as considered before). Therefore, knowledge in electromagnetics (EM) and microwave engineering, together with passive and active RFICs, RFIC analysis and design techniques, and RF systems, is vital for RFIC engineers. Without EM and microwave engineering foundation, RFIC engineers would lack the essential background needed for designing RFICs at high frequencies. The primary objective of the book is to present the theory, analysis, and design of passive and active RFICs, including those at high frequencies beyond those in the traditional RF spectrum, aiming toward providing essential knowledge in RFIC design to graduate students and engineers. The materials in this book are self-contained and presented in such details that allow readers with only undergraduate electrical engineering knowledge in EM, RF and circuits to understand and design RFICs. The book includes problems at the end of each chapter, allowing readers to reinforce their knowledge and practice their understanding. Some of these problems are relatively long and difficult, and may thus be more suitable for class projects. The book can serve not only as a textbook for graduate students and senior undergraduate students (to some extent), but also as a reference book for practicing RFIC and microwave engineers. It is written based partly on the materials of some graduate courses on active RFICs and microwave circuits offered at the Texas A&M University and partly on the RFIC research conducted at the University. The majority of the book can be covered in two graduate semester courses (or two undergraduate courses with reduced load): one for passive RFICs and another for active RFICs.

I sincerely appreciate some of my former students (Drs. M. Miao, Y. Jin, X. Guan, M. Chirala, R. Xu, and S. Lee) for their enthusiasm in venturing into the RFIC area with me and for their contributions, and my

current Ph.D. students (C. Huynh, J. Lee, D. Lee, K. Kim, S. Jang, Y. Luo, Y. Um, J. Bae, and C. Geha) for continuing carrying out our passion in RFICs and for their help in preparing the book. Without them, our venture into RFICs would not have succeeded and this book would hence never been completed. Finally, I wish to express my deepest appreciation to the person I forever owe my indebtedness to: my wife, Ngoc-Diep Tran, for her support during the writing of this book.

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