Preface

Ten years ago, analog seemed to be a dead-end technology, or at best a "niche" area to be tolerated as a necessary evil. The world was inevitably becoming digital—what do we need from analog? Today, the world is amazingly digital, and yet the inevitable consequence is an explosion of analog design interest. An ever-increasing level of integration is the hallmark of today's IC market. Complete systems that previously occupied one or more boards are now integrated on a few chips or even on one chip — a so called *System-on-Chip* (SoC). Although most functions in such integrated systems are implemented with digital or digital signal processing (DSP) circuitry, the circuits needed at the interface between the electronics and the continuous-valued outside world are analog circuits. These analog interface components are being integrated on the same die for reasons of cost and performance. Modem SoC designs are therefore increasingly mixed-signal designs, and this will even be more prevalent in the future.

Interestingly, this has put significant pressure on the CAD tools and methodologies that support the analog parts of these system designs. Although analog circuits typically occupy only a small fraction of the total area of mixed-signal ICs, their design is often the bottleneck in mixed-signal systems, in design time and effort as well as test cost. Analog components are embarrassingly often the ones responsible for chip-level design errors and expensive reruns. And the situation is getting worse. Just as deeply scaled CMOS technologies have complicated the design of digital functions with issues such as complexity management and predictable timing closure, likewise these deeply scaled technologies complicate the analog subsystems on SoC designs. Since analog circuits exploit (rather than abstract away) the low-level physics of the fabrication process, they remain difficult and costly to design, validate, and reuse.

In the digital domain, we have come to depend on the ability of CAD tools to synthesize our logic, map it onto arbitrary libraries, transform logic to layout, verify layout against logic, and optimize both to meet tight timing/power goals. Indeed, the ASIC revolution of the 1990s would have been impossible without these design automation tools.

So, where are the *analog* CAD tools? This volume is our attempt to answer the question. Although the most common strategy for analog is still hand-crafted full-custom design one transistor at a time, one polygon at a time—the situation is now changing rapidly. Today, new circuit and physical synthesis tools are designing practical analog circuits; new modeling and analysis tools are allowing rapid exploration of system-level alternatives; new simulation tools are giving accurate answers for analog circuit behaviors and interactions that were considered impossible to handle only a few years ago. Our goal for this volume has been to collect in one place the essential set of analog CAD papers that form the foundation for the wealth of new analog design automation work we see today.

Some of these papers have been selected to give the reader a better understanding of the history of the field, while others really present a snapshot of state of the art in a particular topic. We have organized the papers into eight areas:

I. **Introduction to Analog CAD:** two general survey papers, giving a broad overview of the field.
II. **Analog Synthesis:** techniques to transform performance specifications into sized circuits.
III. **Symbolic Analysis:** techniques to extract symbolic performance equations from analog circuits.
IV. **Analog Layout:** techniques to transform from circuit to mask, for cells and for mixed-signal systems.
V. **Analog Modeling Analysis:** techniques to fit reduced/simplified macromodels for analog circuits, and analysis methods for common analog concerns such as coupling and noise isolation.
VI. **Specialized Analog Simulation:** techniques to simulate over-sampled converters, switched-capacitor filters, mixed analog/digital circuits, behaviorally represented circuits, and radio frequency (RF) designs.
VII. **Analog Centering and Yield Optimization:** techniques to optimize analog designs for manufacturing yield.
VIII. **Analog Test:** techniques to test analog and mixed-signal designs.

Of course, given this extremely broad range of topics, space limitations have forced many difficult trade-offs; many worthy papers could not be included. As a result, we have chosen to emphasize in this volume the synthesis related topics (parts II — IV), and then to specialize the modeling (part V), simulation (part VI) and optimization (part VII) areas to problems unique to analog macromodeling and analog verification, and to limit the test work (part VIII) to only a few broad survey papers. With the material contained in this volume, the energetic reader should be able to gain a solid understanding of the historical progress in this area, and a good global picture of the current state of the art in analog CAD. This book is therefore intended not only for researchers in the field, but also CAD professionals responsible for implementing or maintaining analog / mixed-signal tools, and the circuit designers who depend on the resulting tools.

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