Chapter 15
Advances in Analog Integrated Circuit Optimization:
A Survey

Prakash Kumar Rout
Silicon Institute of Technology, India

Debiprasad Priyabrata Acharya
NIT Rourkela, India

Umakanta Nanda
Silicon Institute of Technology, India

ABSTRACT

In a system though the analog circuits occupy very less space but they require far more design time than the digital circuits. This is due to the fact that the number of performance measures of an analog circuit is more than those for digital circuits. Predicting and improving the performance, robustness and overall cost of such systems is a major concern in the process of automation. In the automation process, optimization of performances subjected to a verity of environmental constraints is a central task. In this chapter, efficient analog circuit sizing techniques and their optimization are surveyed.

INTRODUCTION

Advances in semiconductor manufacturing technology have resulted in ultra large scale integration (ULSI) of circuits. The complex system-on-chip contains mixed digital and analog circuits. Although analog circuits occupy a small fraction of silicon area but it is highly difficult to design these circuits due to their complexity, noise sensitivity and performance tradeoffs. It is worth noting that the real world is analog and the analog signals need to be processed in integrated circuits (IC). Whatever may be the advancements in digital IC designs the performance of the system is always dictated by the analog part of the integrated circuit. Without automation and optimization the analog IC design suffers from long design time, high complexity, high cost and suboptimal performance. It's no wonder that building ef-

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ficient analog integrated circuits is said to involve some amount of black magic. Because of this analog design require skilled craftsmen who are in short supply. Since the average analog circuit takes longer to implement than its usually much larger digital counterpart. Problems multiply if the analog design is destined to be a block on a mixed-signal or system chip. Hence there have been great efforts not only for design automation but for performance optimization too. When automation helps in handling the design complexity, optimization helps to attain near-best performance in a very less time which can be accomplished by acceptably moderate skilled designers. Here optimization techniques and their applications to analog integrated circuits are reviewed.

The major building blocks of the analog circuits are operational amplifiers, filters, oscillators, low noise amplifiers, power amplifiers and current and voltage sources. The optimization techniques are generally applied to these circuits to estimate their design parameters for obtaining best performance. Many researchers designate this process as circuit sizing. This has two major purposes: first it replaces cumbersome and adhoc manual tradeoffs by automatic evaluation of design parameters, second, it solves problems which are difficult for hand design. Moreover the optimization algorithms also take into account the constraints in the design space.

Section 2 provides a bird's view on the analog IC design flow and scope for various optimizations therein. The conventional and classical technique based analog IC optimizations are discussed in section 3. The use of evolutionary techniques for the analog IC optimization are presented in section 4. Finally section 5 provides the summary and concluding remarks.

ANALOG IC DESIGN AND SCOPE FOR OPTIMIZATION

The Complexity of the Analog IC Design

The performance of analog integrated circuits is very much detrimental in the system performance. The performance specification contains requirements on the various performance metrics of the circuit. Here the performance metric are measures of properties that are used to characterize the behavior of an analog cell. For example an amplifier is characterized by gain, speed, power consumption, linearity and the like. All these performance metrics are very often competing in nature and hence present challenging tradeoffs in the design. This is represented as the analog design octagon which is illustrated in Figure1 (B. Razavi, 2010).

The Analog IC Design Process

The analog design starts with the specifications and the functionality to be implemented which is mapped onto an architectural description for the design. In this process the decomposition of the required function is carried out until we arrive at easily manageable analog building modules or blocks, usually called as cells.

High level models are used to perform simulations to validate the functionality of the concept. The specifications on the low-level modules or cells are extracted from these simulations. The cells are realized by designing the low-level building blocks which comply with the performance requirements. After the physical design of all the required cells the analog system is assembled. The assembled system layout is released for fabrication. The post fabrication testing and verification confirms the release of the product prototype for field deployment. The analog IC design flow is depicted in Figure 2.