Chapter 4
Design Automation, Modeling, Optimization, and Testing of Analog/RF Circuits and Systems by Particle Swarm Optimization

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ABSTRACT

This chapter is an overview of the applications of particle swarm optimization for circuits and systems. The chapter is targeted for the Analog/RF circuits and systems designers. Design automation, modeling, optimization and testing of analog/RF circuits using particle swarm optimization is presented. Various applications of particle swarm optimization for circuits and systems are explained by examples.

1. INTRODUCTION

Analog/RF Circuits are complicated to design as a lot of design constraints are there such as power, area, linearity, noise etc. Due to these complexities, Designing of Analog/RF circuits require experienced designers and design intuitions. To make the design process simple, Design Automation is used. Electronic Design Automation (EDA) tools are used extensively from many years, for the automated design of such circuits. EDA tools simplifies this design process by facilitating the automatic designs for given design specifications. A goal is set for the simulator and an optimization algorithm is associated with that. The algorithm (defined within the EDA tool) searches for the best possible solution in the given design space with the given design constraints. These algorithms are either deterministic or stochastic. Since

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deterministic algorithms are not efficient for the complex designs, stochastic algorithms are used majorly.

Particle Swarm Optimization (PSO) is a popular meta-heuristic algorithm which lies in the group of nature inspired algorithms. PSO is based on the social behavior of the birds flocking and fishes schooling. Particle Swarm Optimization (PSO) has also been widely used for design automation, optimization and testing of Analog/RF circuits and systems. This chapter discusses the various applications of PSO for Analog/RF circuits and systems, with supporting examples. The objective of this chapter is to provide the readers an insight of a wide range of applications of PSO for Analog/RF circuits and systems. Various applications of PSO for circuits and systems, are discussed and supported by examples such as optimization, modeling, design automation and testing etc. As mentioned above, the Analog/RF circuits are complicated with many design constraints, multi-objective optimization is used in most of the examples.

The organization of the chapter is in the following manner. Section 2 describes about RF/Analog circuit design and automation. There are four subsections which show examples of circuit design and optimization such as in-loop optimization by EDA tools, modeled NP problem solution by PSO etc. Section 3 is regarding the modeling of circuits and elements, with example of an on-chip inductor modeling. In section 4, a system level power integrity problem is discussed for high speed systems. This is an optimum capacitor selection and placement problem. Section 5 is about the application of PSO in testing of circuits by N-terminal based testing method. Section 6 shows the designing of passive circuits by PSO. Section 7 describes variants of PSO and their use for circuits. The last section of the chapter, Section 8 concludes the chapter.

2. RF/ANALOG CIRCUIT DESIGN AND AUTOMATION: VARIOUS APPLICATIONS OF PSO

In this section, different types of applications of PSO for circuit design and automation is described. This is the area where PSO is mostly used, in context of circuits and systems.

2.1 Automatic Circuit Design: In Loop Optimization with CAD

PSO, when clubbed with CAD tools, is used for automatic electronic design of Analog/RF circuits. In this process, an objective function is defined in the design tool and based on this objective function PSO is applied. PSO can be implemented in the design tool itself or in any other computational tool which can communicate with the design tool. Based on the objective function, the design is iterated by PSO algorithm. This can be called as in-loop optimization because for each particle CAD tool needs to be run for each iteration. The number of computations are more in this process. In literature such method is used many times for automatic circuit design and optimization (Fakh-

Figure 1. Design process: In Loop Design and Optimization (Fakhfakh et al., 2009) (permission taken from the author for reuse of figure)