Chapter 3
MO–TRIBES for the Optimal Design of Analog Filters

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ABSTRACT

The authors present the use of swarm intelligence in the analog design field. MO-TRIBES, which is an adaptive user-parameter less version of the multi-objective particle swarm optimization technique, is applied for the optimal design of a versatile building block, namely a CMOS current conveyor transconductance amplifier (CCTA). The optimized CCTA is used for the design of a universal filter. Good reached results are highlighted via SPICE simulations, and are compared to the theoretical ones. The use of such adaptive optimization algorithm is of great interest in the analog circuit design, as it is highlighted in this chapter.

INTRODUCTION

Up to date, automated design methodologies and tools for analog, mixed-signal and radiofrequency (AMS/RF) circuits, still lag behind the digital ones (Fakhfakh, M., Tlelo-Cuautle, M., & Fernandez F.V., 2011; Barros, M.F.M., Guilherme, J.M.C., & Horta, N.C.G., 2010). This is due to the fact that the latter is relatively easier to transform into different levels of abstraction so that algorithmic approaches can reduce the complexity of the design process. Besides, digital design is based on practices that are already established, i.e. the use of IPs (digital intellectual property) that has led to a considerable increase in the design productivity (Fakhfakh, M., Tlelo-Cuautle, M., & Fernandez F.V., 2011; Barros, M.F.M., Guilherme, J.M.C., & Horta, N.C.G., 2010). AMS/RF design has thus become the 'bottleneck' in the design flow of the integrated circuit industry. This has caused the so-called '*productivity gap*', i.e. the difference between what technology can offer and what can be manufactured (Barros, M.F.M., Guilherme, J.M.C., & Horta, N.C.G., 2010). As a mean of fact, tremendous efforts are being deployed by

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researchers and R&D engineers to develop new design methodologies in the AMS/RF domains.

Actually, these domains form a trilogy in the realm of AMS/RF circuit and system design, namely: Synthesis, Design Methodologies and Optimization. Endeavors are being made to develop new synthesis techniques, design methodologies and sizing/optimization techniques.

This Chapter deals with the third aggregate, i.e. Optimization. Indeed, due to the wide complexity of AMS/RF circuits and systems, the sizing and optimization task in the AMS/RF design field has always been considered as a knowledge intensive, iterative and multiphase chore that highly relies on the designer's experience (Barros, M.F.M., Guilherme, J.M.C., & Horta, N.C.G., 2010; Tlelo-Cuautle, E., Guerra-Gómez, I., de la Fraga, L.G., Flores-Becerra, G., Polanco-Martagón, S., Fakhfakh, M., Reyes-García, C.A., Rodríguez-Gómez, G., & Reyes-Salgado, G., 2010, Barros, M., Guilherme, J., & Horta, N., 2010). This is mainly due to the large number of constraints, companion formula, and objective functions that have to be handled.

Thus, optimization techniques have been explored, mainly the statistic-based sizing approaches and related ones, see for instance (Toumazou, C., Moschytz, G., & Gilbert, B., 2010; Medeiro, F., Rodríguez-Macías, R., Fernández, F.V., Domínguez-Astro, R., Huertas, J.L., & Rodríguez-Vázquez, A., 1994; Su, H., Michael, C., & Ismail, M., 1994; O'connor, I., & Kaiser, A., 2000; Graeb, H., Zizala, S., Eckmueller, J., & Antreich, K., 2001; Jespers, P.G., 2009).

Some heuristic-based mathematical approaches were also used, such as simulated annealing, tabu search, genetic algorithms, etc. (Barros, M.F.M., Guilherme, J.M.C., & Horta, N.C.G., 2010; Grimbleby, J.B., 2000 ; Dinger, R. H., 1998 ; Marseguerra, M., &. Zio, E, 2000; Durbin, F., Haussy, J., Berthiau, G., & Siarry, P., 1992; Courat, J.P., Raynaud, G., Mrad, I., & Siarry, P., 1994; Fernandez, F.V., & Fakhfakh, M., 2009; Guerra-Gomez, I., Tlelo-Cuautle, E., McConaghy, T., & Gielen, G., 2009 ; Han, D., & Chatterjee, A., 2004; Li, Y., 2009; Conca, P., Nicosia, G., Stracquadanio, G., & Timmis, J., 2009). As it is already well known, these techniques do not offer general solution strategies that can be applied to problem formulations where different types of variables, objectives and constraint functions are used (Fernandez, F.V., & Fakhfakh, M., 2009). In addition, their efficiency is also highly dependent on the algorithm parameters, the dimension and the convexity of the solution space, etc.

Few years ago, a new optimization technique was proposed, it is called Swarm intelligence (SI) (Chan, F.T.S., Tiwari, M.K., 2007; http1).

In short, SI is an artificial imitation of the decentralized and self-organized collective intelligence of some homogeneous agents in the environment, such as schools of fish, growth of bacteria, herding of animals, flocks of birds, and colonies of ants. The main basic idea consists of artificially reproducing the social behavior of such animals. These animals are considered as a kind of particles interacting with each other and with their environment. Even though these particles' behaviors obey to simple rules, with no centralized control structure, they present a very intelligent overall behavior that is unknown to the individual particle (Chan, F.T.S., Tiwari, M.K., 2007; http1; Bonabeau, E., Theraulaz, G., & Dorigo, M., 1999).

Among the SI techniques, and due to its simplicity, i.e. little number of user-parameters, facility of integration, and inexpensive requirement of memory, Particle Swarm Optimization (PSO) is relatively the most popular SI technique (Chan, F.T.S., Tiwari, M.K., 2007; http1; Bonabeau, E., Theraulaz, G., & Dorigo, M., 1999; Kennedy, J., Eberhart, R.C., 1995; Clerc, M., 2006; http2; http3; Clerc, M., &. Kennedy, J., 2002; Fakhfakh, M., Cooren, Y., Sallem, A., Loulou, M., & Siarry, P., 2009; Reyes-Sierra, M., & Coello-Coello, C.A., 2006).

In general, metaheuristics (including PSO) are algorithms of which performances can be highly dependent on the chosen user-parameters values.

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