Automated Passive Filter Design Using Multi-objective Genetic Algorithms with Variable Parameters

José Matias Pinto
Instituto de Telecomunicações
Instituto Superior Técnico
Torre Norte, Av. Rovisco Pais, 1
1049-001 Lisboa, Portugal.
josempinto@ist.utl.pt

Nuno Horta
Instituto de Telecomunicações
Instituto Superior Técnico
Torre Norte, Av. Rovisco Pais, 1
1049-001 Lisboa, Portugal.
nuno.horta@lx.it.pt

ABSTRACT
A system to automate the design of passive filters using a multi-objective approach is presented on this work. A fixed but flexible structure is used to code the chromosome representing the circuit topology. An automated procedure is developed to size the circuit components from a given set of specifications. The novelty of this work is the multi-objective approach, where, for one side, priority is given to smaller circuits with less components, but, on the other side it must obey with the performance specifications. The ability of the proposed tool was tested on the design of several filter specifications.

Categories and Subject Descriptors

General Terms
Algorithms, Experimentation, Performance.

Keywords

1. INTRODUCTION
Despite digital electronic is present in almost any decent and recent electronic device, the analogue circuits are still an indispensable part of almost any electronic gadget currently in use, from cell phones to car electronics. Unlike digital design, analogue design still requires the skills of specially trained designers and engineers. Circuit-level analog synthesis is a two step process, namely topology selection and component sizing [3]. In [1] Angan Dass, & al. (2007) presented a skeletal structure to automate the topology generation and component sizing of passive analog filters. The authors used a variable (in size) structure organized as a linked list to describe the chromosome representation of the circuit. In this work the authors do not mention how the size of the evolved circuits is controlled but this is important, because a chromosome of variable length is used, which can grow infinitively or in an uncontrolled way. This work proposes a new multi-objective genetic algorithm approach to explore both topology and sizing of passive filters.

2. METHODOLOGY
The proposed system consists on a Genetic Algorithm coupled with a circuit evaluation module. The linking between the two is the fitness function based on the accomplishment of the desired circuit specifications.

2.1 Template Circuit
The proposed system generates complete circuits by evolving a connected network of passive components and subsequently placing this network in a predefined template circuit. This single-input single-output template circuit is shown in Figure 1.

2.2 Chromosome Genetic Encoding Scheme
Each population of the Genetic Algorithm consists of multiple candidate solutions known as chromosomes. A chromosome consists of several genes. In this work, a gene symbolizes a circuit part. So each gene should contain the information pertinent to: 1- Value of the element; and: 2- Type of Element which can be: Resistor, Capacitor or Inductor, the possibility of it being a Short Circuit or an Open Circuit has been added to allow the evolution of different topologies. This work proposes the use of a circuit in the form of a matrix conforming to the topology represented in the Figure 2, where each Z represents a circuit element; it can be either: R, L, C, SC or OC. For the experiments presented in this study the maximum dimension is limited to a 4 by 3 matrix, but these limits can be changed by the user. It is true that this representation exclude certain circuit topologies, but it is still capable of generate a rich set of them counting many of the useful topologies seen in hand-designed circuits, furthermore it also increases the probability of generating structurally correct circuits.

2.3 Circuit Evaluation
An essential step, so that any evolutional strategy can work is the evaluation of the solution quality, in this case, the circuit topology. Here, two measures, objectives, will be considered: the error or distance to the desired performance and the circuit complexity.
3. RESULTS

In order to validate the proposed tool the design of several filters were performed. Here, the results are illustrated for a high-pass filter specification.

In the template circuit, the values for RSource, RGND, ROut and LOAD have been fixed respectively to the following values: 1KΩ, 1mΩ, 1mΩ and 1KΩ. The selected high pass filter had the following specifications: Kp = 0.0 dB, Ks = 90.0 dB, f0 = 1000 Hz and fp = 100 Hz, adopting the same conventions used in [1].

In Figure 3 the final population, as well as, the Pareto front (blue line) are presented. The solution with Complexity 17 got the best result on objective F1. The evolved filter circuit is presented on figure 4 which verifies the required specs.

4. CONCLUSIONS

A methodology and a tool were proposed for the automatic topology generation and sizing of passive filters using the state-of-the-art multi-objective genetic algorithm. The proposed tool was demonstrated in the design of several filter specifications getting competitive results with the related work.

5. REFERENCES

