Application of the Maximum Principle
for the Circuits Optimization

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Abstract—The solution of the problem of computational time reduce during optimization of electronic circuits allows to enhance the development quality. Generalized methodology of the circuits optimization developed before on a basis of optimal control allows to define many different optimization strategies. Definition of Lyapunov's function of optimization process and its analysis for different strategies allows to compare these strategies from viewpoint of computational burden and select the best of them. At the same time the most grounded approach for the search of optimal development strategy in this statement is Pontryagin maximum principle. But application of this principle for solution of non-linear problems is related to essential complications. In this paper it is obtained the solution of electronic circuit optimization problem during minimal amount possible processor time on a basis of Pontryagin maximum principle in general case of N variables. It is shown that effect studied before for acceleration of the process of optimization coincides the solution on a basis of the maximum principle. This fact is the theoretical explanation of the acceleration effect. From the other hand the principle of maximum can be the basis for development of the algorithm for electronic circuits optimization with minimal processor time cost.

INTRODUCTION

The possibility of processor time reduce which is necessary for approach of minimal point of the goal function of optimization process can be realized by means of reducing of time for the system analysis and enhancing of the optimization procedures. Due to the structure of conductance matrix of the electronic circuit is sparse many conceptions for operation with sparse matrixes are realized successfully [1]. Another approach to decrease of the operations amount for the electronic circuits analysis is related to decomposition idea [2].

Different methods for analog circuits optimization can be classified with two main groups: determined optimization algorithms and stochastic search algorithms. Some drawbacks of classic determined optimization algorithms are requirement of good initial estimate in the parameters space, unsatisfied local minimum appear, which can be achieved, and frequently the requirement of the goal function continuity and differentiability. To overcome the mentioned problems the special methods are used. For example the centering method for definition of the process initial point [3], the methods of geometric programming [4], allowing to obtain the convergence to the global minimum, but from the other hand requiring special statement of the equations of the design problem, which is related with additional complications. Another approach is based on a method of space map [5] whose purpose is to achieve the satisfactory solution with minimal calculation amount for accurate reference estimations by means of large-scale model optimization.

Stochastic search algorithms, such as evolution algorithms, genetic algorithms, genetic programming, and particles swarm optimization, etc. were developed last years [6–14]. Genetic algorithms are used as a subroutine for analog circuits optimization due to their possibility to find satisfactory solution. Special algorithm defined as method of particles swarm optimization is one of evolution algorithms and it compete with genetic algorithms. This method is applied successfully for optimization of the microwave systems [13, 14].

At the same time restatement of the circuits optimization problem without accurate satisfying of Kirchhoff law proposed in [15–17] opens new possibilities in the design problem. The most common problem statement of the problem of analog circuits design is given in [18, 19]. It is shown such approach allows to generalize the statement of the problem of electronic circuits design and obtain many different

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