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A Structure of Time Minimal Strategy of Analog Circuits Optimization

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Abstract—An application of optimal control theory allows to generalize method of analog circuits optimization. A task of search of time minimal strategy of circuits optimization is stated as a classical problem of optimal control theory functional optimization. As an optimized functional there is total processor time. At that, the main tool is controlling function vector, which allows to redistribute processor time burden between circuit analysis task and parametric optimization procedure. Introduced earlier special function, which is normalized Lyapunov's function of development process, allows to predict total processor time of circuit development using initial development period. This function also allows to find optimal or quasi optimal controlling function vector behavior for minimization of circuit optimization process time.

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Reduce of analog circuits optimization time allows to increase development quality and to decrease costs. In addition to traditional ideas of time reduction due to sparse matrices and decomposition methods application, we propose a method, allowing to reduce circuits development due to restatement a development problem, ignoring Kirchhoff laws satisfaction during optimization process [1]. This idea was realized in two development systems [2, 3] in its extreme variant, i.e. totally ignoring Kirchhoff laws satisfaction. More general analog circuits development problem statements were given in papers [4–6] on a base of control theory terms. At that the task is stated as problem of selection of one or several optimization strategies of almost infinite set of development strategies, appearing during optimization process. These strategies must realize optimization process during minimal time. A main tool is a vector of controlling functions, which allows to redistribute processor time burden between analysis task and optimization procedure. Optimization procedure is stated as dynamic process [7]. In papers [4–6] it is shown that traditional development strategy is not time optimal. At that, optimal or quasi optimal strategy has time profit, which grows with dimensions and complexity of developed circuit growth. In optimal development strategy building a structure of controlling functions vector is essential. In particular, optimal structure of this vector defines optimal development strategy in sense of operational speed. With purpose to compare we introduce in paper [8] special function, which allows to select optimal strategy. In this paper this function is used for optimal structure of controlling functions vector determination.

Analog circuits development according to proposed methodology [4–7] is defined as dynamical controlling process. This process is defined by differential equations of state variables, dependently on selected statement of optimization procedure, which can be continuous or discrete. As a restriction system for optimization procedure we select mathematical model of electronic circuit.

In continuous form an optimization procedure can be written as following system of differential equations:

$$\frac{\mathrm{d}x_i}{\mathrm{d}t} = f_i\left(\mathbf{X},\mathbf{U}\right), \quad i = 1,\ldots,N, \tag{1}$$

where right parts of equations, i.e. functions $f_i(\mathbf{X},\mathbf{U})$ are defined by optimization method, for example, for gradient method, they are written as: