ISSN 0735-2727, Radioelectronics and Communications Systems, 2007, Vol. 50, No. 11, pp. 603–608. © Allerton Press, Inc., 2007.
Original Russian Text © A.M. Zemliak, 2007, published in Izv. Vyssh. Uchebn. Zaved., Radioelektron., 2007, Vol. 50, No. 11, pp. 26–35.

Analysis of Dynamic Characteristics of Process of Designing Analogue Circuits

A. M. Zemliak

Independent University of Carmen, City of Carmen, Mexico
National Technical University of Ukraine "Kiev Polytechnic Institute," Kyiv, Ukraine

Received in final form December 18, 2006

Abstract—The process of designing analogue circuits is formulated as a controlled dynamic system. For analysis of such system's properties it is suggested to use the concept of Lyapunov's function for a dynamic system. Various forms of Lyapunov's function are suggested. Analyzing the behavior of Lyapunov's function and its first derivative allowed to determine significant correlation between this function's properties and processor time used to design the circuit. Numerical results prove the possibility of forecasting the behavior of various designing strategies and processor time based on the properties of Lyapunov's function for the process of designing the circuit.

DOI: 10.3103/S0735272707110039

Basic concepts of a new methodology in designing analogue circuits in terms of the control theory were stated in previous works [1, 2]. It was shown that the new approach potentially allows to significantly decrease the processor time used to design the circuit. This quality appears due to a new possibility of controlling the design process by redistributing computational burden between the circuit's analysis and the procedure of parametric optimization. It may be considered to be a proven fact that traditional design strategy (TDS) including the circuit's analysis at every step of its design is not optimal with respect to time. More over the benefit in time used to design the circuit for some optimal or more precisely quasioptimal strategy compared to TDS increases with increasing size and complexity of the designed circuit [3]. This optimal strategy and corresponding design's trajectory were obtained using special search procedure and serve only as a proof existing strategies which are much more optimal than TDS. However, it is clear that the problem lies in the ability to move along an optimal trajectory of the circuit's design process from the very beginning of designing the circuit. Only in this case it is possible to obtain the mentioned potentially tremendous advantage in time which corresponds to the optimal design strategy. During the building the optimal strategy and its corresponding trajectory at the present moment it is necessary to analyze their most significant characteristics. The study of the optimal trajectory's qualitative characteristics and their differences from those of the other trajectories appears to be the only possible way to solve the problem.

The discovery of an effect expecting additional acceleration of the design process [4] and exploration of conditions determining this effect's existence [5] lead to increased time advantage and serve as an initial point of quasioptimal design strategy building. The analysis of this effect allowed to state three most significant moments:

1) to obtain the acceleration effect the initial point of the design process should be chosen outside the domain limited with a special hypersurface (separatrix),

2) the acceleration effect appears during a transition from a trajectory corresponding to a modified traditional design strategy (MTDS) to the trajectory which corresponds to TDS and from any trajectory similar to MTDS to any trajectory similar to the trajectory of TDS,

3) the most significant element of the acceleration effect is an exact position of the point corresponding to a transition from one strategy to another.

According to the suggested methodology the process of designing an electric circuit is defined as a controlled dynamic system. This system is described with differential or difference equations for the state variables and a set of limitations defined by the electric circuit's mathematical model. Difference equations for system's variables may be written in the form:

$$x_i^{s+1} = x_i^s + t_s \times f_i(\mathbf{X}, \mathbf{U}),\ i = 1, 2, \ldots, N. \quad (1)$$