Dynamical Systems and Their Applications
June 22 - 26, 2015, Kyiv, Ukraine

Stabilization of systems with multiple power nonlinearities

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In this paper we solve the stabilization problem for a class of nonlinear systems with uncontrollable first approximation. Namely, we consider a nonlinear system of the form

$$\begin{cases} \dot{x}_1 = u, \\ \dot{x}_i = x_{i-1}^{2k_{i-1}+1}, \quad i = 2, \dots, n \end{cases} \tag{1}$$

where $k_i \in N$, $u \in R$ is a control. The stabilization problem for system (1) is to construct a control of the form $u = u(x)$ such that equilibrium point of the closed-loop system is asymptotically stable.

We assume that $k_1 = \cdots = k_s = 0$ and $0 < k_{s+1} < \ldots < k_{n-1}$ for some s such that $0 \leq s \leq n-2$. For $s = n-2$ the stabilization problem for system (1) has been solved in [1]. The main result of the present work states that a stabilizing control can be found in the form

$$u(x) = a_1 x_1 + a_2 x_2 + \cdots + a_n x_n + \sum_{i=s+1}^{n-1} a_{n-s+i} x_i^{2k_i+1}. \tag{2}$$

The conditions on coefficients a_i are obtained with the help of the Lyapunov function method. A Lyapunov function $V(x)$ can be chosen in the following form $V(x) = (Fx, x)$ where F is a solution of a singular Lyapunov inequality.

References

[1] M. O. Bebiya, *Stabilization of systems with power nonlinearity.* Visn. Khark. Univ., Ser. Math, Prykl. Mat. Mekh. **Vol 1120** (2014), P. 85 – 94.