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HIGH ORDER SLIDING MODE AND ITS APPLICATION ON THE TRACKING CONTROL OF PIEZOELECTRIC SYSTEMS

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Abstract. *Aiming at a kind of piezoelectric actuator (PEA) with hysteresis nonlinearity, a new high order sliding mode controller (HOSMC) is presented. Firstly, the two-order nonlinear dynamic model of the PEA is introduced and the hysteresis nonlinearity part is analyzed as a kind of bounded disturbance acting on the system. Then, the high order sliding mode control law is designed. Further, the finite-time astringencies of the sliding mode variables and the asymptotic astringency of tracking error variable are proved theoretically. The simulation results show the validity of the HOSMC for this kind of piezoelectric actuators with hysteresis nonlinearity.*
Keywords: High order sliding mode, Tracking control, Piezoelectric actuator, Dynamic hysteretic model

1. **Introduction.** In recent years, an issue in variable structure control (VSC) theory ([5,13,18-20]), which is to design "chattering-free" continuous control, becomes more and more important in practical applications. Many methods [3,7,17] have been presented to reduce the chattering effect. To mitigate chattering in the system, approximations to the control signal are often made. Saturation and sigmoid functions, for example, are used as "filters" for the output of a discontinuous signal in order to obtain a continuous one. A drawback of continuous approximation methods is the reduction of the control accuracy. One of the most recent topics in VSC theory is represented by the high order sliding mode control(HOSMC) methodology [1,6,10,12]. The HOSMC technique retains the main advantages of SMC and also yields more accuracy.

By now, many papers on applications of the HOSMC have been published. Hebertt [11] studied the second order sliding mode control of the hovercraft. Alfonso [2] proposed a 2-SMC algorithm to synthesize a robust dc-drive control system which does not require current feedback and demands only rough information about the actual motor parameters. S. Laghrouche [15] dealt with the robust control problem of a permanent magnet synchronous motor subjected to parameters uncertainties and load disturbance with a second order sliding mode approach. G. Bartolini [9] dealt with the hybrid position force control of constrained manipulators subjected to uncertainties, which is based on high order sliding-mode control theory. M. K. Khan [14] proposed a novel high order sliding mode control algorithm for robust control of liquid levels in interconnected twin-tanks.

In this paper, we adopt the high order sliding mode method to implement the tracking control of the piezoelectric actuators with hysteretic nonlinearity. Firstly, by analyzing the