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HYBRID CONTROLLER DESIGN FOR A MECHANICAL TRANSMISSION SYSTEM WITH VARIABLE COMPLIANCE AND UNCERTAINTIES

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Abstract. *This paper proposes an integrated hybrid control strategy with singular perturbation analysis and adaptive robust control to precisely position a transmission system with variable compliance and model uncertainties. Control input determined by singular perturbation analysis is introduced to compensate for the reduced-order model based on a rigid-body system. The robust control gives the system better tracking performance at the predicted error convergence rate, and the adaptive control provides the system with a fast adaptation mechanism to maintain control performance under the influence of model uncertainties and unknown disturbances. The simulation and experimental results show encouraging control performance using the proposed approach.*
Keywords: Compliant axis, Adaptive control, Robust control, Singular perturbation analysis, Transmission system

1. **Introduction.** In mechanical systems, transmission mechanisms are responsible for transferring energy from the power source to a remote site, changing the type of motion to achieve the designated objectives. In general, the transmission mechanism has been modeled as a rigid component by ignoring the compliance between these two ends. To enhance mechanical performance, most researchers have focused on the power driving end or the controlled end of the transmission system [1-3], etc. However, the compliance mechanism between these two ends usually causes difficulties in designing controller based on rigid dynamic models. For example, the inherent friction and compliant characteristics of transmission mechanisms often seriously degrades the whole system's performance and induces oscillation in the positioning mechanism [4,5].

With respect to the compliance property, Ortega and Spong [6] explored the flexible problem of the robotic system and introduced two nonlinear control techniques, the feedback linearization technique and the integral manifold technique, for flexible robots. McAskii and Dunford [7] proposed a self-tuning pole-placement method for the positioning control of a manipulator with flexible joints. They applied real-time parameter estimation, which was calculated by the autoregressive moving-average method, to update the controller's model and thereby approach the control target. Er et al. [8] proposed a multirate output and input PID controller for a two-link flexible-joint robot by using a digital-signal-processor (DSP). This method outperforms the traditional PID control in the areas of maximum overshoot, rise time and steady-state error, except for the larger setting time. Ider [9] developed an inverse dynamic control algorithm to achieve position and force control in constrained flexible-joint robots. Complex differential geometry as