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ROBUST ADAPTIVE SLIDING MODE CONTROL FOR TRIAXIAL GYROSCOPE

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Abstract. *This paper presents an adaptive variable structure controller with on-line identification of the upper bounds of uncertainties and disturbance for MEMS triaxial angular sensors device that is able to detect rotation in three orthogonal axes, using a single vibrating mass. A robust adaptive sliding mode controller is developed and the stability of the closed-loop system can be guaranteed with the proposed adaptive robust sliding mode control strategy. The on-line identification of the upper bounds of uncertainties and disturbance can be incorporated into sliding mode controller to alleviate the chartering. The proposed adaptive sliding mode controller updates estimates of all stiffness, damping errors, input rotation parameters, upper bound of uncertainties and disturbance in real time, removing the need for any offline calibration stages. The numerical simulation for MEMS gyroscope triaxial angular sensor is investigated to verify the effectiveness of the proposed robust adaptive sliding mode control scheme.*
Keywords: Sliding mode control, Adaptive feedforward control, Vibration suppression

1. **Introduction.** Gyroscope is commonly used sensor for measuring angular velocity in many areas of applications such as navigation, homing and control stabilization. Gyroscopes are the devices that transfer energy from one axis to other axis by Coriolis force. Fabrication imperfections always result in some cross stiffness and cross damping effects, and the performance of the MEMS gyroscope is also hindered by the effects of time varying parameters as well as noise sources such as thermal and mechanical noise and sensing circuitry noise, environment variations, quadrature errors, parameter variations, and external disturbance which generate a frequency of oscillation mismatch between the two vibrating axes. It is necessary to control the MEMS gyroscope using advanced controllers.

Sliding mode control is a robust control technique which has many attractive features such as robustness to parameter variations and insensitivity to external disturbance. Adaptive control is an effective approach to handle parameter variations. Adaptive sliding mode control has the advantages of combining the robustness of variable structure methods with the tracking capability of adaptive control strategies.

Utkin [1] introduced the variable structure system and showed that variable structure control is insensitive to parameters perturbations and external disturbances. Sliding mode controllers have been successfully applied in [15-18]. Narendra [2], Astrom [3], Ioannou and Sun [4], and Tao [5] described the adaptive controls. The adaptive control law, merging parameter identification and sliding mode, was proposed and analytically studied by