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DESIGN OF ROBUST ADAPTIVE INTEGRAL VARIABLE STRUCTURE ATTITUDE CONTROLLER WITH APPLICATION TO FLEXIBLE SPACECRAFT

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Abstract. *A robust control system for rotational maneuver of an orbiting spacecraft with flexible appendages is designed. Based on variable structure control theory, a discontinuous attitude control law is derived to achieve the desired position of the spacecraft, taking explicitly into account external disturbance and nonlinearity. To reconstruct estimates of the system states for use in a full information control law, an asymptotic variable structure observer is also employed and the fulfillment of sliding condition, including the case when estimated states are used, is verified as well. An additional attractive feature of the control system design is that an adaptive mechanism is embedded such that the unknown upper bound of lumped perturbation is automatically adapted. Compared with conventional adaptive proportional-derivative (APD) control, the developed control scheme not only guarantees the stability of the closed-loop system, but also yields better performance and robustness in the presence of parametric uncertainties and external disturbance. Simulation results are presented for the spacecraft model to show the effectiveness of the proposed control techniques.*

Keywords: Flexible spacecraft, Integral variable structure control (IVSC), Attitude maneuver, Adaptive control

1. **Introduction.** Modern flexible spacecrafts are expected to achieve highly accurate pointing and fast maneuvering from large initial conditions as well in the presence of large environmental disturbances and structural deformations of the flexible parts. The design of such control system is a challenging task for the control engineers, especially when complete knowledge of the external disturbances and coupling nonlinear terms is not available. In recent years, several relative studies have been done (Byers, Vadali & Junkins, 1990; Singh, Kabamba & McClamroch, 1990) and efforts have been made to design robust and nonlinear control systems as well (Nagata, Modi & Matsuo, 2001; Karray, Grewal, Glaum, etc. 1997; Grewal & Modi, 1996). Variable structure control (VSC) scheme has long been recognized as an effective means to improve transient response and achieve robust performance (Drakunov & Utkin, 1992; Hung &Gao, 1993). For different mission objectives (Vadali, 1986; Dwyer & Sira-Ramirez, 1988; Crassidis & Markley, 1996; Lo & Chen, 1993, 1996), various control techniques have been developed and compared for the rigid spacecraft. For the flexible spacecraft model, finite mathematical discretization was used to design sliding mode controllers and there have been significant research efforts for the general feedback attitude control of flexible spacecraft (Hu &Ma, 2005;