Active Vibration Suppression of Flexible Satellite With Appointed Time Convergence

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Abstract. In this paper, an appointed time active vibration suppression controller is studied for flexible satellite with piezoelectric actuators. Firstly, a piecewise sliding mode controller with the appointed time is designed to guarantee that the attitude error converges at the appointed time. The convergence time of the model can be set with a prior parameter. Secondly, a modal observer is used to estimate the vibration of the flexible elastic modal, and an active vibration suppression controller is designed to converge at a predefined time. The stability of the two controllers is demonstrated by a Lyapunov theory. The Simulink simulation framework is eventually established, and the numerical simulation results of various data demonstrate the appointed time convergence of the proposed controller. Compared with adaptive sliding mode and nonsingular terminal sliding mode, the controller can achieve higher precision control with less energy consumption.

Introduction

Flexible satellite attitude control can be divided into two aspects: maneuvering pointing control and flexible vibration suppression. Maneuvering pointing control is a nonlinear problem with disturbance and uncertainty. The main control methods are robust control, sliding mode control, adaptive control and deep neural network control. Early research in the field of flexible vibration suppression includes passive vibration suppression methods of vibration isolation, energy dissipation, and vibration absorption. However, the control effect of passive vibration suppression is limited and the applicable environment is limited[1]. Therefore, many scholars have studied active vibration suppression. There are three main active vibration suppression methods applied in the aerospace field: component synthesis vibration suppression(CSVS), input shaping and active vibration control based on intelligent materials[2].

Results and discussion

We specify that the desired attitude quaternion of the satellite is $\boldsymbol{q_d} = [1, 0, 0, 0]^T$. The initial value of the attitude quaternion is $\boldsymbol{q} = [0.8832, 0.3, -0.2, -0.3]^T$. To verify the appointed time convergence performance of the proposed controller, the model parameters and other parameters of the controller are kept constant, the appointed time T_a is set to 100, 200, and 300. The result is shown in Figure 1.

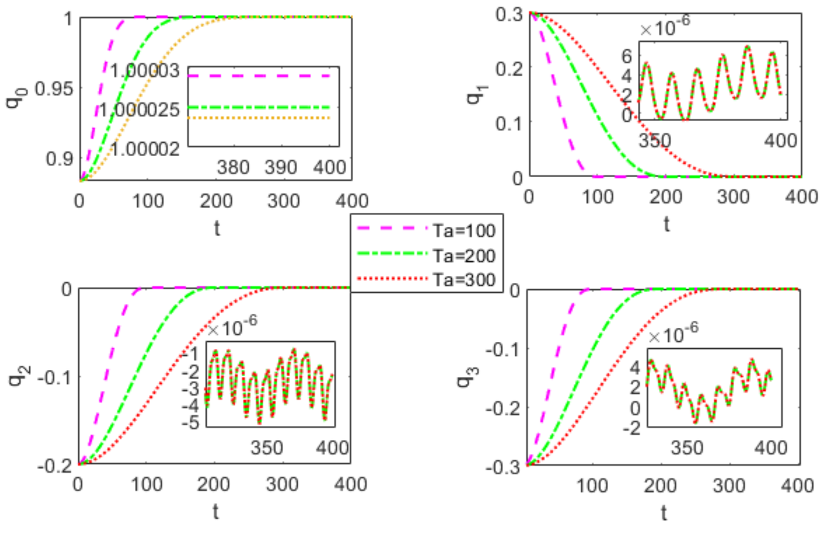

Figure 1: Attitude quaternion at three different convergence times

Even in the presence of external perturbations and model uncertainties, the appointed time sliding mode controller can directly appoint the convergence time of the attitude error, which is independent of the initial conditions of the model.

References

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[2] S. Xu, "Dynamic modeling and on-orbit vibration control research for flexible spacecraft," Ph.D. dissertation, Harbin Institute of Technology, 2019.