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ACTIVE DAMPING ALGORITHM OF THE INTERNATIONAL SPACE STATION STRUCTURE VIBRATION

Abstract

At present Russian segment thrusters are used to perform attitude maneuvers of the International Space Station (ISS) in "Thruster Only" control mode. As the thrusters operate in pulse mode, every turn-on and turn-off leads to the ISS structure vibrations. With the increase of the station dimensions and consequent reduction of its stiffness these vibrations become significant and lead to exceeding of the structure loads. Active damping of the elastic vibrations using attitude control thrusters are proposed to solve this problem. In this paper the same set of thrusters operating in the pulse-width modulation mode is proposed to be used both for rigid body control and for active damping. The algorithm analyzes the current state of angular motion in the phase plane. The active damping of the ISS vibrations modes begins when the phase point describing the object rigid body motion gets inside the dead zone of a relay control algorithm. In this case the relay control signal to the actuators is based on estimation of elastic vibration angular rate in the location of the angular rate sensor (ARS). Thus, the rigid body motion control and the active damping of elastic vibrations are separated in time. The rigid body angular rate estimation and the vibration components estimation at the dominant tones of elastic vibrations in ARS location are used as input information to analyze the current state of angular motion. These estimations are generated in the adaptive observer. The adaptive observer is an adjustable real time on-board dynamics model of control object that includes a model of the ISS structure vibrations. The natural frequencies and the influence coefficients of the thrusters on the amplitude of ISS elastic vibration are adjusted. These parameters are identified by recurrent gradient-search method in every on-board computer processing frame. Particular attention is paid to the analysis of the convergence of the identification algorithm estimations and stability of active damping algorithm. Operability and effectiveness of the algorithm are confirmed by the results of mathematical simulations. The proposed algorithm prevents against the excess of the ISS elastic vibration limits, that significantly reduces structural loads during attitude maneuvers and while maintaining the designed attitudes.