

Dynamics modeling and attitude control of a flexible space system with active stabilizers

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Abstract Attitude control of rigid-flexible multi-body systems by active stabilizers is studied in this paper. During slewing maneuvers, flexible members like solar panels may be excited to vibrate. These vibrations, in turn, produce oscillatory disturbing forces on other subsystems and consequently produce error in the spacecraft motion. Also, to develop a proper model-based controller for such complicated system, the system dynamic model is derived. However, due to practical limitations and real-time control implementation, the system dynamic model should be structured such that low computations burden will be imposed on the model-based controller. In this paper, in contrast to many accumulating dynamic modeling approach, a precise compact dynamic model for an active stabilized spacecraft (ASS) system with flexible members is derived. Toward this goal, the total system is virtually partitioned into two rigid and flexible portions. Moreover, the obtained model of these complicated systems

is vigorously verified using ANSYS and ADAMS programs. Finally, based on the derived dynamics and a proper virtual damping parameter, an attitude control algorithm is then developed. The suggested controller structure takes the advantage of utilizing the piezoelectric smart materials to dissipate the vibration of solar panels. The obtained results reveal the merits and effectiveness of the proposed suggested modeling and control methods for reliable attitude maneuvering of the system. In addition, it will be shown that the undesired vibrations of the flexible solar panels result in disturbing forces on the ASS system which can be significantly eliminated by the proposed attitude control algorithm.

Keywords Rigid-flexible multi-body systems · Reaction wheel · Piezoelectric patch · Attitude control

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List of symbols

| | |
|--------------------|---|
| B_f | Virtual damping matrix of flexible member |
| C | Vector of quadratic nonlinear terms of velocity |
| H | Positive definition mass matrix of system |
| J_c | Jacobian matrix for the spacecraft |
| J_f | Jacobian matrix of the floating frame of each flexible body |
| K | Stiffness matrix of flexible member |
| K_p, \tilde{K}_d | Gain matrix of controller for system in task space |
| K_{PZ} | Capacitances of the piezoelectric patches |

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