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THE CONTROL OF SPACE TETHERED SYSTEM

Abstract

In this work the dynamics of a space tethered system that consists of a big satellite moving along an Earth orbit and smaller satellites attached to the bigger one with the help of flexible long tethers is considered. The dynamics of the system with small loads moving along the tether is also considered in this work. The problems of dynamics of such tethered systems are correct deploying and then dynamical control and stabilization of the whole system in the needed orientation with respect to the orbit. The problem of simultaneous dynamic stabilization and suppressing of transverse and longitudinal vibrations of deploying space tethered system with smaller satellite moving along a certain pre-calculated trajectory is considered and solved. It is proved that it is possible to control the behavior of the tether and the smaller satellite by controlling the tension of the tether and the angles of deviation from some needed trajectory at the other endpoint. The mathematical model is set and the analytical and numerical analyses of the boundary control problem are completed based on Lyapunov method. The nonlinear partial differential equations of longitudinal and transverse waves describe the dynamics of the system. It can be shown that in the case of a periodic regime at the boundary for the deploying tethered system there always occur resonance phenomena in the tether which lead to unlimited growth of the amplitude of transverse and longitudinal waves. This effect cannot be determined without using partial derivative equations. The principal mechanism of deploying is proposed for dynamic boundary control for the stable movement of the whole system. The mechanism involves one control torque and the transverse movement of the boundary. The movement of the whole system can be controlled with checking transverse displacement and tension at one endpoint of the tether at the bigger satellite. After the system is deployed small containers are able to move along the tether. These containers can be used for "orbit-mail" and for utilizing space debris to lower or upper orbits. The proposed control mechanism allows to stabilize the movement of such containers with small load and the tether. That also allows to control the movement of the whole system. Numerical simulations confirmed the effectiveness of the proposed mechanism of control.