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Space Structures - Dynamics and Microdynamics (3)

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PLACEMENT OPTIMIZATION OF PIEZOELECTRIC SENSORS IN A CLAMPED-FREE PLATE LIKE SOLAR PANEL ON A LARGE SPACE STRUCTURE

Abstract

Piezoelectric materials have the property to convert mechanical energy associated with elastic deformation to electrical energy and vice-versa. Those kinds of materials can work as sensors and/or actuators on space structure with the aim of elastic vibration damping. In designing spacecraft attitude and control subsystems (ACS) it may be required to study and analyse the elastic vibration effects on the the attitude motion and on pointing devices depending on the mission pointing requirements. If piezoelectric sensors and/or actuators are chosen then the correct placement of the sensors and/or actuators on the elastic part of the space structure is mandatory to guarantee a good performance of the ACS. The procedure to obtain the best placement for those devices is optimization. This paper deals with the placement optimization of PZT sensors on a solar panel for a Large Space Structure (LSS) in a low Earth orbit (LEO) under the effect of the gravity-gradient torque. The LSS mathematical model is obtained by the Lagrangian formulation for generalized coordinates combined with the Lagrangian formulation for quasi-coordinates. The assumed mode method is used to represent the elastic displacement so as to allow the complete motion equations to be described by ordinary differential equations. The shape function critical points are determined and used for the PZT sensor placements. A modified LQR technique is used to implement the whole system attitude and vibration control in which the state weighting matrix includes the sensor outputs. That state matrix is in general arbitrary but satisfying the positive semidefiniteness requirements. In this work it is still arbitrary but in addition to those requirements a new requirement is imposed on the state matrix by including the sensor output signals. Also this work takes into account the temperature effect on the PZT sensor output information used for the sake of attitude and vibration control.