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DYNAMIC DEVELOPMENT AND JITTER CONTROL FOR SATELLITES WITH MAGNETIC SUSPENDED VARIABLE SPEED SINGLE GIMBAL CONTROL MOMENT GYROS

Abstract

Because variable speed single gimbal control moment gyros(VSCMGs) are capable of generating large or fine control torques, and storing large angular momentum over long periods of time, they are far more promising for future remote-sensing spacecrafts required ultra-high precise attitude control and rapid maneuverability. However, the rotor imbalance is generally the main jitter source in VSCMGs and induces the high frequency disturbance force and torque on spacecrafts. To control at sources is the most effective way attenuating vibrations and restraining attitude jitter, and the developing control technology of active-magnetic-bearing(AMB) provides a valid method to deal with this question. First, a system model is developed to describe the translational and rotational motion of an AMB suspended rotor in a VSCMG on a satellite. It is crucial to define non-spinning coordinates of the quasi-geometric body frame and the quasi-principal-axis frame which make it viable to present the form of the rotor dynamics formulas in these coordinates: (1)Computing of the AMB force acting on the rotor becomes easy to carry on. (2)Since the precession and nutation of the rotor are small due to the nature of the AMB suspension system, singularities in rotational kinematical differential equations can be avoided with non-repeated indices. (3)The relation between principal axis of inertia and bearing centerline to be modeled is simple by dynamic and static imbalance variables. This model strictly reflects the motion characteristics of the rotor by considering the dynamic and static imbalance as well as the coupling between the gimbal's and the rotor's motion on a satellite platform. The result can be used in AMB control system design. Second, a general case with an unknown principal axis of inertia is considered, and the adaptive auto-centering control is carefully constructed for the rotor with unknown dynamic and static imbalance. The rotor makes its rotation about the principal axis of inertia through identifying the small rotational angles between the geometric axis and the principal axis as well as the displacements from the geometirc center to the mass center with the help of eddy current sensors or optical sensors, so as to tune a stabilizing controller composed of decetralized PD controllers with cross-axis proportional gains and high- and low-pass filters. Based on the theory of linear periodically time-varying system and character loci of MIMO system, the verification of the control system stability is fulfilled. Furthermore a normalized least-mean-square adaptive filter is designed for the same question.