ABSTRACT

A magnetically actuated satellite attitude control system is proposed. The equation for ideal torque is designed in terms of the errors in the attitude and the relative angular velocity components. This ideal torque is used to calculate the necessary dipole moment on the magnetic torquers and the torque developed by the interaction of magnetic torquers with Earth's magnetic field. The controllability of the three axes magnetic controller is proved for the averaged system dynamics throughout the orbit for any arbitrarily high initial angular velocity and proved periodicity of geomagnetic field was not a necessary requirement. A PD control is proposed to control the orientation and angular velocity of an Earth pointing satellite and the controllability and global stability of the proposed system is proved. It is proved that attitude control of an Earth pointing satellite can be achieved using magnetic actuators and a fast finite-time continuous sliding mode controller. A new nonlinear sliding manifold is proposed and used to design an average finite-time continuous sliding control. It is proved that the proposed continuous finite-time sliding control is equivalent to the average sliding control derived from the averaged system dynamics. Temporal controllability and global stability of the proposed control system is proved for high angular velocities. It is proved that the system states converged to the sliding manifold and further to the origin fast and in finite time even in the presence of disturbing torques. In addition, a fault tolerant magnetically actuated attitude control system for the Earth-pointing satellite is proposed. The controllability of the system on an average after the failure of a magnetic actuator is proved. The local and global stability of the two actuator attitude control system with a PD controller is proved even for high angular velocities after reconfiguration. It is proved that an iso-inertia satellite attitude can be controlled and stabilized using two axes time invariant feedback control, which is not possible with other control strategies even using time varying control methods. Finally, a nonlinear robust backstepping control is designed and implemented for controlling a satellite with destabilizing gravity gradient moment. It is shown that the proposed controller almost effectively compensates external disturbances and uncertainties in moments of inertia matrix as considered in the satellite dynamics. The stability of the system for a high angular velocity is proved for the proposed controller and it is shown that it is exponentially stable in the neighborhood of the origin with the proposed controller. All proofs are validated with detailed simulation studies.