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SYNTHESIS OF PROGRAM ANGULAR MOTION REGIMES FOR THE MAGNETIC ATTITUDE CONTROL SYSTEM OF SPACECRAFT

Abstract

The angular motion of a spacecraft (SC) under magnetic control is considered. Number of practical and scientific problems that are solved with the aid of small SC is growing. The magnetic attitude control system are easy to manufacture and can significantly reduce costs of SC, making them more accessible for wide use. Besides, such system ensures a longer service life of the SC due to the durability of the magnetic coils. However, its significant drawback is the limitation in the direction of the control torque. It is impossible to create a magnetic torque along the geomagnetic induction vector. The paper proposes a synthesis of special angular trajectories, which allows bypassing this limitation. The approach consists of three stages. The first stage is the search for the optimal approximation of the geomagnetic field over a certain given time interval. Then, at the second stage, a special angular trajectory is constructed, which guarantee the control torque being perpendicular to the geomagnetic induction vector during SC movement along this trajectory. This makes it possible to follow this angular motion using magnetic control only. Second stage uses the geomagnetic field induction vector founded at the first stage. At the third stage, the optimal control gains are sought to ensure asymptotic stability based on the approach using the Lyapunov function. At each of the listed stages, optimization is carried out using the particle swarm optimization method. To reduce trajectory tracking errors in the full model numerical simulation, the above three steps are repeated every three revolutions. This is necessary for better geomagnetic field approximation and, consequently, for better real control torque realization by the magnetic attitude control system. When switching between intervals occurs, to ensure the smoothness of control, the continuity of the second derivatives of the program torque is guaranteed by the procedure of "splice" the trajectories. "Splice" is implemented by decreasing the number of independent parameters (coefficients) of the trajectory at the second stage on all intervals, starting from the second. This approach to constructing a controlled angular motion allows reducing implementation errors and improving the accuracy of the final attitude, which reaches several degrees at worst case scenario.