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FROM MAGNETIC TO AERODYNAMIC PASSIVE STABILIZATION: CASE OF TRANSIENT ATTITUDE MOTION OF TNS-0#2 NANOSATELLITE

Abstract

Passive attitude control systems are quite popular for nano-, pico-, femto-satellites due to strict limitations in terms of mass, size, cost and energy. These systems utilize natural magnetic, gravitational or aerodynamic torques to provide stabilization appropriate for the mission. The ratio between the values of these major environmental torques changes as the satellite orbit evolves. The paper studies the transient attitude motion using telemetry data from TNS-0 #2 nanosatellite.

Technological NanoSatellite TNS-0#2 developed by JSC Russian Space Systems was successfully launched on August 17, 2017 from the International Space Station during the spacewalk of the Russian cosmonauts. The mass of the satellite is 4.8 kg and the form-factor is hexagonal prism. The main feature of the TNS-0 nanosatellite series is the GlobalStar communication system. The TNS-0 satellites upload and download the telemetry and other information via GlobalStar antennas. The satellite is equipped with the passive magnetic attitude system developed by the Keldysh Institute of Applied Mechanics of RAS. The system consists of a set of hysteresis rods for the initial angular velocity damping and a permanent magnet located along the axis of symmetry to stabilize the axis along the local geomagnetic field induction vector. Three-axis magnetometer and a set of sun sensors are installed onboard. Attitude motion is reconstructed using their measurements.

After the damping of the initial angular velocity after the launch the satellite achieved a passive magnetic stabilization. The longitudinal axis of the satellite was directed approximately along the local geomagnetic induction vector with deviation that does not exceed 12 degrees. This attitude was provided with the passive magnetic control system. However, due to the natural altitude decrease aerodynamic torque influence increased. The satellite has a relatively elongated geometry with significant displacement between the centers of mass and pressure. On September 1, 2019 the magnetic attitude changed to almost chaotic motion with high angular velocity. In about 2 days the aerodynamic stabilization was achieved, which maintained till the breakdown in the atmosphere on September 6, 2019. The details on the transient attitude motion and its analysis are given in the paper.