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MAXIMIZATION OF THE DOMAIN OF TOLERANCE OF SPACECRAFT WITH AIR-BREATHING ELECTRIC PROPULSION ON PROBABLE VARIATIONS OF CHARACTERISTICS OF ULTRA-LOW EARTH ORBITS AND IONOSPHERE

Abstract

Spacecraft (SC) in ultra-low (150-250 km) Earth orbits have significant advantages for carrying out traditional tasks. Long-term maintenance of satellites in such orbits is possible using air-breathing electric propulsion (ABEP), which utilizes the outboard gases of the rarefied atmosphere as a propellant. An essential feature of ABEP in comparison with other types of engines, including common electric propulsion, is their deep integration with the spacecraft layout.

In this paper, we solve the problem of integrated optimization of such layout with the maximum expansion of the altitude range of circular sun-synchronous orbits (SSO), where compensation of the atmospheric drag is possible at all times. Various missions are considered, including multiyear ones. The available specific power of solar arrays per orbit revolution is determined on the assumption that the axis of their possible (optimal) rotation passes through the velocity vector of the SC mass center. The diurnal and seasonal changes in atmospheric characteristics are taken into account at various levels of solar activity.

The optimal layout parameters are found from the numerical solution of a system of nonlinear equations for the necessary optimality conditions. The boundaries of the permissible domain are determined by the continuation method. Investigations of the dependence of the range of SSO altitudes, at which long-term SC maintenance is possible, on the characteristics of the ABEP and the power supply system are carried out. The research results make it possible to determine the maximum range of orbit parameters for spacecraft with ABEP and the requirements for their implementation.