ASTRODYNAMICS SYMPOSIUM (C1)
Attitude Dynamics - Part 1 (5)

Author: Prof. Michael Yu Ovchinnikov
Keldysh Institute of Applied Mathematics, RAS, Russian Federation

Dr. Vladimir Penkov
Moscow Aviation Institute (State Technical University), Russian Federation
Mr. Dmitriy Roldugin
Moscow Institute of Physics and Technology, Russian Federation

ANALYTICAL STUDY OF A THREE-STAGE MAGNETIC ATTITUDE CONTROL TO CHANGE A SINGLE-AXIS ORIENTATION

Abstract

To provide change of orientation of a given axis of a satellite one can use the idea to turn a spinning body while it is axisymmetrical. Feature of such an approach is as following: gyroscope being subjected to a torque rotates while the applied torque acts, i.e. as soon as torque ceases the satellite stops to turn immediately. Consequently, nobody needs to implement a solution of a boundary-value problem to make a turn control of the satellite through acceleration and breaking of rotation in order to reorient a non-spinning rigid body. If it comes to that the approach is accepted as a strategy for attitude control, three-stage algorithm of magnetic attitude control which has been studied in the paper can be applied. Usability is the main feature of the approach.

At the first stage of movement the satellite should be damped in order to avoid chaotic rotation and tumbling due to initial conditions of motion. To decrease a magnetorquer consumption of electrical energy a projection of satellite angular velocity onto its axis of symmetry should be saved at this stage of control. Next, satellite should be spinned-up around the axis of symmetry oriented, generally speaking, in arbitrary direction in the space. At the third stage spinning satellite is subjected by control torque to approach a required direction in the space. Measurements required for the control can be collected and directly used from a sensor like three-axis magnetometer for the first two stages and after data processing using a statistical algorithm for attitude determination at the third stage.

A proper choice of a model of the geomagnetic field allowed us to obtain an explicit solution of equations of the satellite attitude motion at each of three stages of control within certain constrains using asymptotical technique. In general case the solution is numerically obtained and analyzed. The explicit solution shows trend in effectiveness and accuracy with regard to the inclination of orbit and other satellite parameters.

The work is supported by RFBR (grant # 09-01-00431), the Ministry of Education and Sciences of Russia (contract # 02.740.11.0860) and FCT.