849. Novel attitude control devices for CubeSat satellites

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Abstract. In recent years a very modern trend of space exploration activities – constructing, launching and operating nano-satellites, became very popular. One of the main problems in implementation and control of nano-satellite is ensuring accurate yet simple and small-sized attitude control equipment. Most of the equipment implemented for that task in the past was large, bulky and could be hardly used on extremely small CubeSat standard nano-satellites. The equipment under development for attitude control of the satellites is described in this paper. The equipment relies on implementation of piezoelectric transducers for rotation of spherical body – reaction sphere, thus ensuring precise three-axis attitude control of the satellite by means of single device. Description of the device under development with some calculations and examples of implementation of such instrumentation is further described in the paper.

Keywords: nano-satellite, CubeSat, attitude control, reaction-wheel, momentum of inertia.

Introduction

In recent years due to the miniaturization, the instrumentation which used to be large and bulky in the past has decreased its dimensions tenths of times. Recently a brand new trend in science has formed – creation, launching and control of miniature "micro", "nano" and "pico" satellites. Such small satellites have the weight in the range of 1 ... 10 kg and due to their small price and short life cycle, are often used for purposes of education, technology demonstration, technology testing and science experiment.

Fundamental problem in operation of such small satellites is their attitude control. Despite a lot of research in satellite attitude control systems done in the past, all of them were intended for use on large conventional satellites and can hardly be implemented in small satellites due to bulkiness and large weight. Generally there exist several technical spacecraft attitude control solutions:

1. Implementation of thrusters (of different principles);
2. Magnetic (passive or active);
3. Inertial;
4. Gravitation;
5. Aerodynamic;
6. Solar wind.

The most precise mean of attitude control of spacecraft is implementation of inertial forces. One of such systems - implementation of "reaction wheels" - wheels of high enough mass producing torque opposite to the acceleration of its rotation [1, 2]. In usual systems implemented till this day, the fly wheels were accelerated (and rotated) by means of electric motors, due to that three of reaction wheels were required to control the attitude of satellite in all three axis. The quantity of needed reaction wheels together with complexity of electrical motor itself determined large mass and high price of the precise attitude control system [3, 4].

The instrument described in the paper implementing reaction sphere (instead of reaction wheels) could allow satellite three axis attitude control by means of single instrument (instead of three independent reaction wheels) [5]. Though the idea of implementation of reaction spheres