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Piezoelectric Devices for Attitude Control of Pico and Nano-Satellites

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Abstract



In recent years a very modern trend of space exploration activities – constructing, launching and operating of nano and pico-satellites became very popular. One of the main problems in implementation and control of nano and pico-satellites is ensuring of accurate but simple and small dimension 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 satellites.



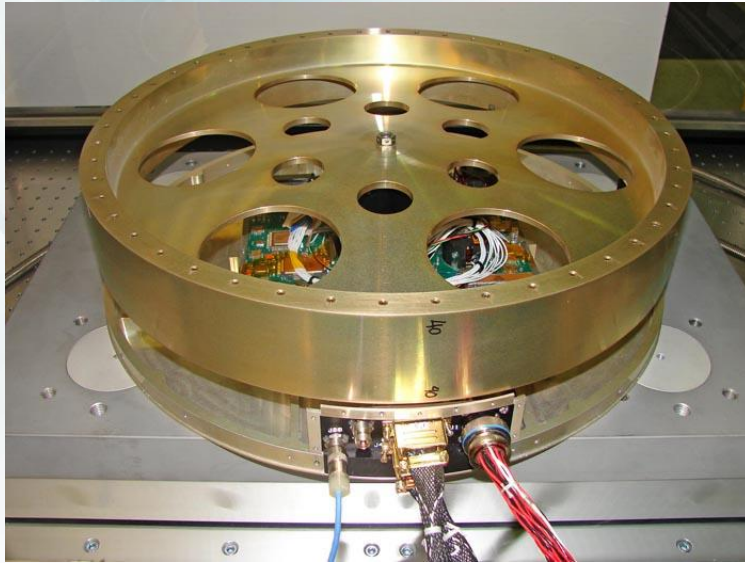
Objectives



- Develop a piezoelectric device for attitude control of pico and nano-satellites
- Test the new developed equipment in Earth and Space



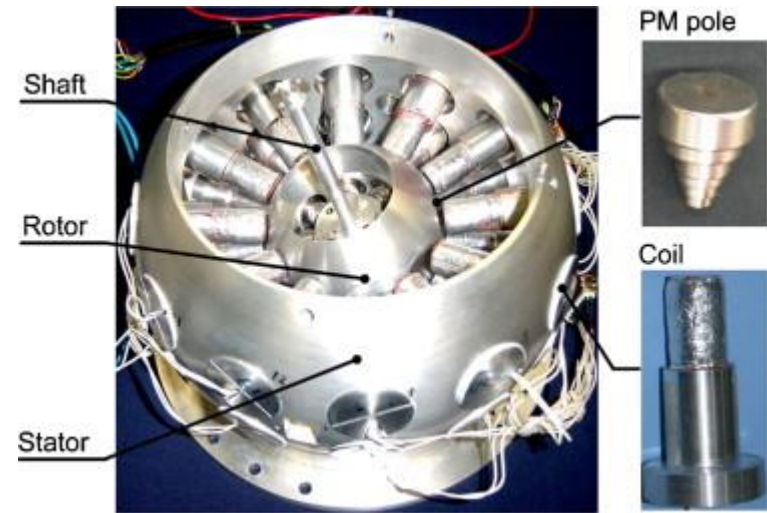
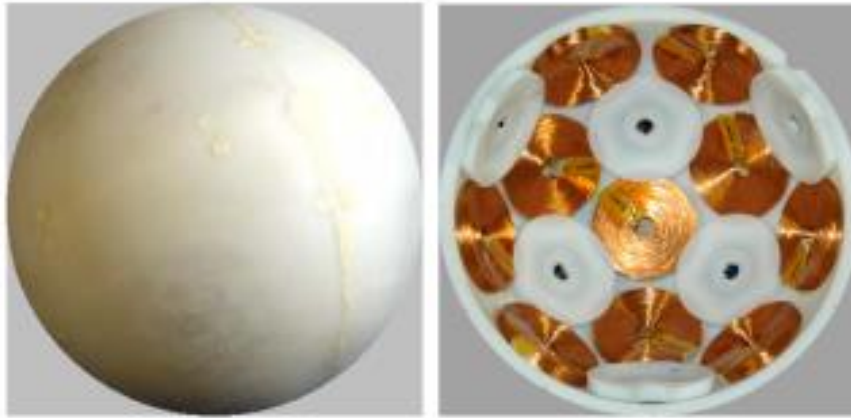
Reaction wheel



- Reaction wheels long been the mean of most precise attitude control of equipmet



Reaction sphere



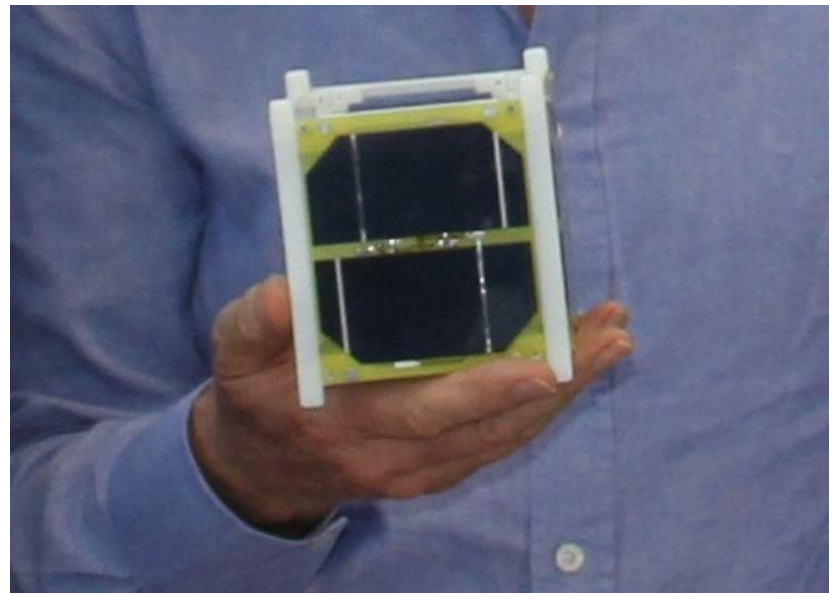
- Reaction spheres have been developed, but still are large and bulky



Nano and pico-satellite terminology



- Small satellites have the weight in the range of 0,1 ... 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.



Lithuanian nano-satellite “LIT-SAT 1”



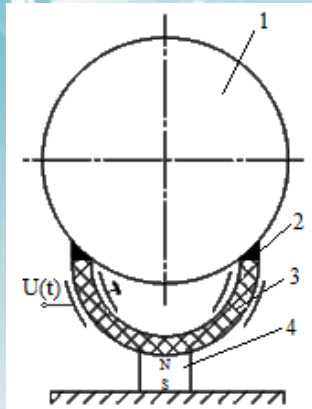
Attitude Control



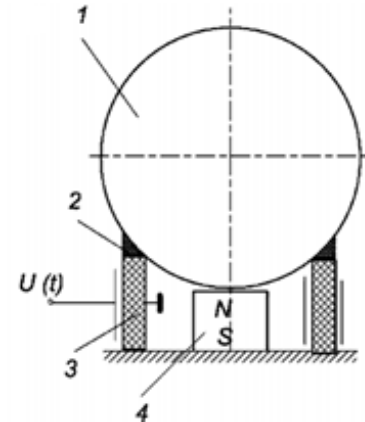
- Generally there exist several technical spacecraft attitude control solutions:
 - 1. Implementation of thrusters (of different principles);
 - 2. Magnetic (passive or active);
 - 3. Inertial;
 - 4. Gravitation;
 - 5. Aerodynamic;
 - 6. Solar wind.



Piezoelectric actuators



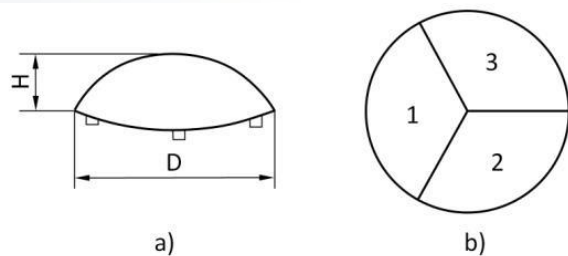
- 1 - reaction sphere
- 2 - intermediate element
- 3 - hemispherical piezoelectric element
- 4 - constant magnet



- 1 - reaction sphere
- 2 - intermediate element
- 3 - cylindrical piezoelectric element
- 4 - constant magnet

Construction of the equipment with piezoelectric hemisphere

Construction of the equipment with piezoelectric cylinder



Sectioned electrodes of hemispheric piezo-ceramic transducer

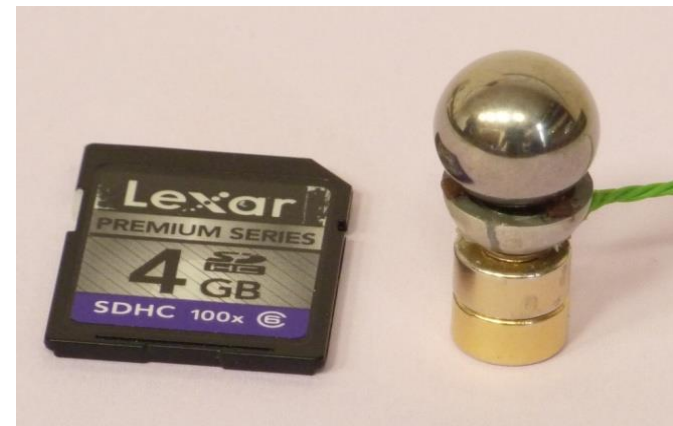
Ferromagnetic reaction sphere 1 is in contact with piezoelectric element 3 via the intermediate element 2. The sphere is held in a position using constant magnet 4. The electrodes of piezo-ceramic 3 is divided into three symmetrical sections, by connecting of which to the electric signal source the rotation is realized.



Prototypes of attitude control devices



Test examples of reaction sphere with cylinder piezoelectric transducer



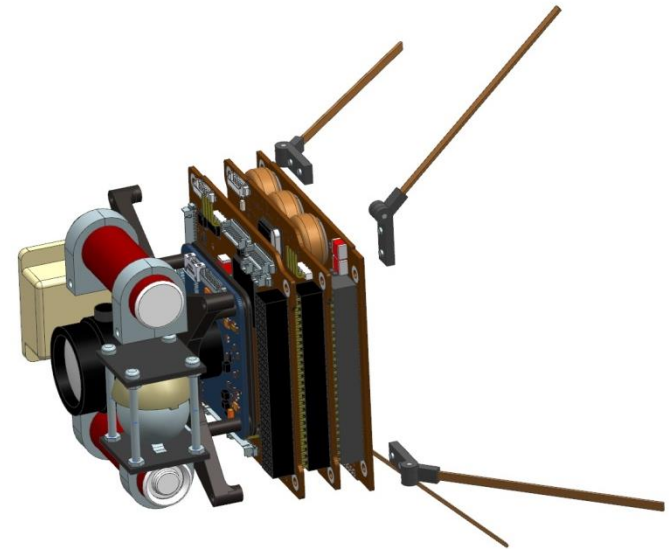
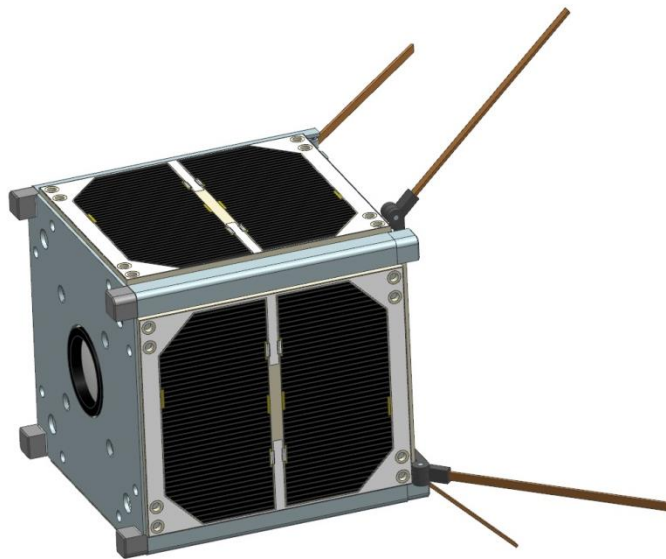
Test example of sphere with hemispheric piezoelectric transducer

The advantages of such hemisphere piezo-ceramics layout are:

- By choosing the topology of electrodes three dimensional oscillations are generated, the parameters of which can be changed by adjusting the frequency of excitation;
- There is a node of oscillations at which the attaching point can be positioned;
- There is a decrease of dimensions in case of implementation of hemisphere (compared to the cylindrical piezo-ceramics shape).

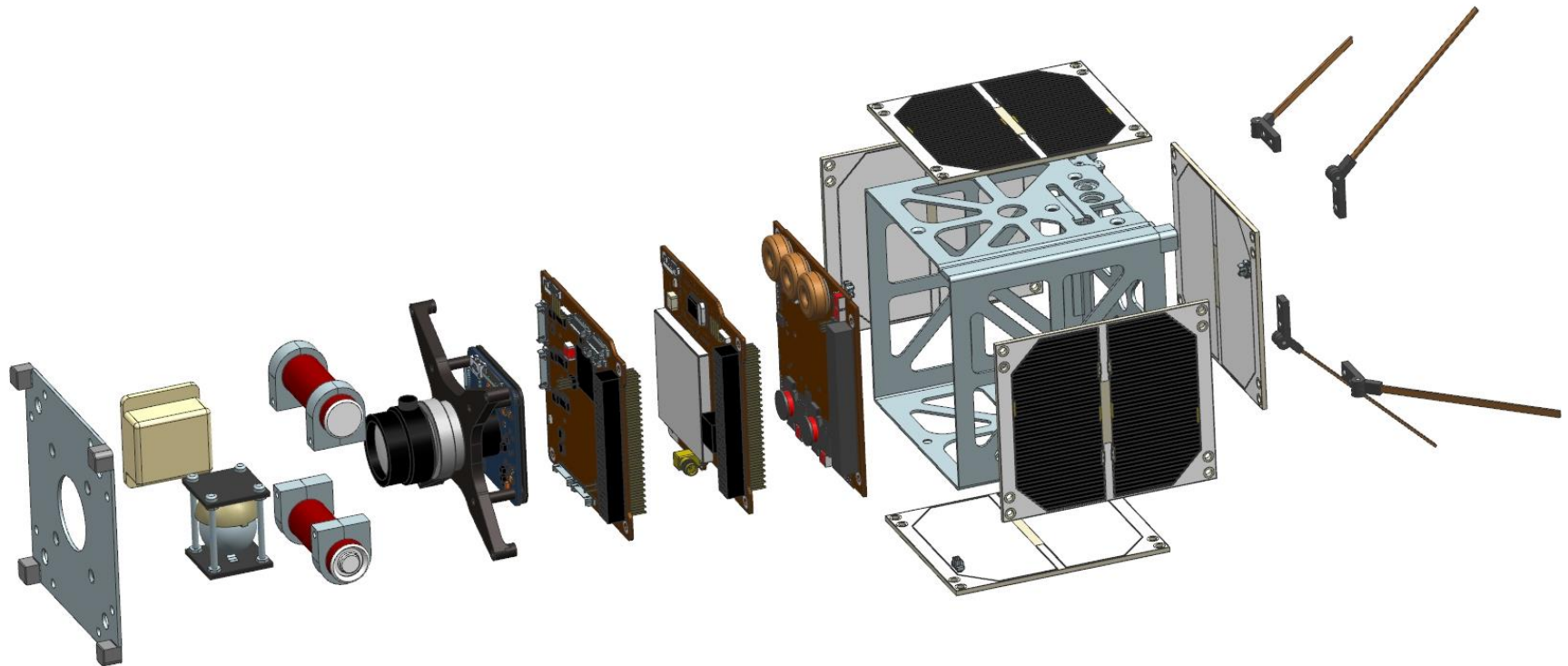


Examples of possible implementation





Examples of possible implementation





Conclusions



The applications of multi degree of freedom piezoelectric motors for attitude control of small satellites is proposed, ensuring accurate orientation, small dimensions and high reliability at extremely low price. Due to unexplored nature of implementation of piezoelectric actuators with several degrees-of-freedom in space environment, further research must be performed to determine the suitability of implementation of piezoelectric devices.

Acknowledgement:

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