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PIEZOELECTRIC ULTRASONIC MOTOR REACTION WHEEL FOR CUBESAT

Abstract

Constructing and launching nano-satellites have become a growing trend in recent years base on low budgets and new technologies. QB50 is one of the ongoing nano-satellite projects, it is aiming to construct a network of about 40 double and 10 triple CubeSats for studying the Earth's Thermosphere and the satellite re-entry process. The technologies in CubeSat missions are relatively more innovative except for attitude control system, the restrictions on size and weight prevent CubeSats from implementing reaction wheels. The majority of the existing CubeSats adopted passive actuators or magnetic torquers, however, to enable precise and fast three axis attitude control, reaction wheel is still the best option. Ultrasonic motor (USM) base on the piezoelectric resonance has become a suitable option for CubeSat reaction wheel under the above considerations, USM has faster response time, higher holding torque, lower noise and simpler structure, and it does not interfere with magnetic field. The immediate objective of this research is to design an USM reaction wheel subsystem for a double CubeSat of QB50 project, this design also includes innovative driver and control mechanism. Firstly, a commercial USM was chosen, and its specifications and properties were studied, then a new driver of the USM with smaller size, fewer components and compatible with pulse-width modulation (PWM) control inputs was designed and constructed. Besides, the structure of the double CubeSat was modified for adapting the reaction wheel subsystem. Eventually, the USM reaction wheel subsystem and the CubeSat were integrated and tested on an air bearing table, the control mechanism was then created base on the experiment results. The results show that the USM reaction wheel has a good performance, especially it is able to overcome the momentum saturation problem by its fast response time to input commands. However, the power consumption is higher than the conventional reaction wheels, and the control mechanism is comparatively complicated and not ideal due to the non-linear property of the USM. The conclusion can be drawn that the USM reaction wheel is efficient in attitude control of the double CubeSat. For achieving a better accuracy, further research should be done in the future on designing simpler and more power efficient driver system, and also more appropriate control mechanism.