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DESIGN, TEST, AND VERIFICATION OF A REACTION WHEEL FOR CUBESATS

Abstract

Khalifa University's initiatives in designing and constructing CubeSats for technology demonstration show a significant leap in advancing space capabilities. The ongoing project involves a 6U CubeSat destined for Low Earth Orbit (LEO) at YahSat space lab. This research primarily focuses on designing, testing, and developing a flight model reaction wheel for integration into the current 6U CubeSat mission at Khalifa University. The design phase involves careful analysis of key factors, such as flywheel design and motor selection from low-cost commercial of the shelf motors, with a primary focus on reducing the weight and size while maintaining optimal performance. Furthermore, a thorough modelling, simulation, and analysis of the reaction wheel are presented, using a Proportional Integral (PI) controller to illustrate the performance of the selected Brushless DC motor under flywheel loading conditions. The results showed that the reaction wheel performs within the expected behavior proving the compatibility of the flywheel geometric properties at the operational speed and torque limits. Furthermore, the paper presents a block diagram of miniaturized flight model reaction wheel with a diameter of only 33mm and a total mass that does not exceed 38g, with a maximum torque of 0.5mNm and the ability to store angular momentum up to 1.32mNms. At the hardware level, the reaction wheel is integrated with a PI controller circuit, initially tuned using a trial and error method. Functional test results similar to the simulation study are illustrated to show the performance of the reaction wheel at different operational modes taking into account all physical factors including friction and vibrations. Finally, the characterization of micro vibrations induced by miniaturized reaction wheels is presented using a developed cost-effective test bed. The in-house development of the reaction wheel contributes to the space heritage of the United Arab Emirates in space systems technology.