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DESIGN AND TESTING OF A MODULAR, COLD GAS PROPULSION SYSTEM FOR SMALL SATELLITE APPLICATIONS

Abstract

Small satellites allow for a faster and less expensive way to perform space missions as compared to larger traditional satellites, and they have grown greatly in capability in the past decade. One area of capability that small satellites are developing is propulsion systems. The development of miniature propulsion systems will enable small satellites to rendezvous with other space objects without relying on larger vehicles for transportation. It is also an important enabling technology for the trajectory correction maneuver and attitude control.

A cold gas propulsion system for small spacecraft orbital maneuvers is developed. The concept behind the propulsion system is the design of high integration, which allows the thruster to make efficient use of the available volume. The propulsion system operates by releasing a saturated liquid propellant serially through a check valve and an electromagnetic valve with a integrated converging-diverging nozzle. The power consumption of the propulsion system is lower than those propulsion systems in literatures because only one electromagnetic valve is used. For the current thruster design, there are no active sensor measurements, such as pressure transducers. Instead, the thruster will be operated passively with two inputs: the desired total change in velocity and the ambient temperature. The results that are presented in this paper provide for a mapping of the expected performance from a given temperature.

The testing of this thruster focused on determining the level of thrust available and the specific impulse of the system. The thrust was measured using a hanging pendulum. This pendulum was suspended in front of the thruster nozzle, and when the thruster fired, it imparted an impulse to the pendulum, which swung away from the nozzle. A displacement transducer measured the total angle of the swing. The impulse of the firing can be determined from this angle. Through extensive tests, the propulsion system was measured with a specific impulse 85 seconds at 15°C. The measured thrust force provided by the propulsion system ranged from 20 mN to 40 mN because of pressure changes in the plenum. This system has a total mass under 1500 grams, including 260 grams of ammonia as propellant. The propulsion system is expected to provide at least 60m/s of delta-v capability, which has been verified through testing. A testing unit of the thruster was assembled and delivered in January of 2017, and the flight unit is scheduled for delivery at the end of 2017.