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DESIGN OF ATTITUDE DETERMINATION AND CONTROL SYSTEM FOR AUTONOMOUS DOCKING OF SMALL SATELLITES

Abstract

Traditionally, majority of docking operations in space have been carried out manually or in a semi-autonomous manner. Autonomous docking of spacecrafts opens up a wide scope of opportunities for satellites in the future such as on-orbit servicing, refuelling, collaborative building of space stations using small modules, etc. forming an integral part of space exploration.

A robust and reliable Attitude Determination and Control System (ADCS) is necessary to satisfy the stringent requirements for docking of small satellites due to low error tolerances imposed by their small sizes. It has to make sure that the docking happens in the right orientation and there is no final relative angular velocity.

Attitude determination for such a mission type can be divided into two phases – absolute and relative. Absolute attitude determination is performed before the final phases of rendezvous and uses conventional sensors such as star tracker, sun sensors etc. Relative attitude determination is performed during the final phases of docking using cameras, etc.

Attitude Control should provide good pointing accuracy and stability even in presence of various disturbance torques. It should also provide 3-axis control of the combined spacecraft considering changes in the inertia tensor and centre of mass.

The work here addresses the challenges involved in the design of ADCS for autonomous docking of small satellites. It addresses selection of sensors for absolute and relative determination methods as well as the switching between them. It also addresses the selection of determination and estimation algorithms based on their accuracy, complexity, computational time, etc. It includes selection of suitable actuators and their placement so as to achieve efficient 3-axis attitude control in both undocked and docked scenarios. The implementation of the control algorithm in the final phases of docking is simulated. Mission profile of a conceptual small satellite docking of two spacecraft – SRMSAT-3A & 3B is considered for design and simulation and the results are presented.

We are part of the ADCS Subsystem at Team SRMSAT, SRM University. The goal was to develop the ADCS for the two small satellites to perform undocking and docking in Low Earth Orbit. We learnt about various determination and control strategies by referring to previous work in the field and came up with a final design suitable for our mission. We had to make many iterations on our design based on constraints given by other subsystems.