IAF SPACE SYSTEMS SYMPOSIUM (D1)
Technologies to Enable Space Systems (3)

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MAGLEV BASED 3-DOF EXPERIMENTAL PLATFORM FOR AUTONOMOUS SPACECRAFT RENDEZVOUS AND DOCKING

Abstract

To enhance the current operational capabilities in the fields of both military and civilian space missions, autonomous close proximity operations, including the capability for timely, on-demand, on-orbit servicing and refueling play a vital role. Realistic validation and testing of such space technologies is the first crucial step before deploying such technology in future spacecraft. There are several challenges associated with experimental testing as they will require a zero-g and friction-free environment. Traditionally, to compensate for gravity and allow free movement, air bearings are generally used. Air bearings push pressurized air through specially designed nozzles to provide an almost friction-free environment. This pressurized air is generally stored in pressurized air tanks that are both, bulky and heavy.

This paper proposes a MagLev based spacecraft simulator which will enable realistic testing of spacecraft maneuvering control laws, especially during proximity operations. Magnetic levitation is used as a way to compensate gravity utilizing the interaction between permanent magnets and eddy currents generated in a thick aluminum sheet. According to Faraday's Law of electromagnetic induction, when a permanent magnet moves in the vicinity of a conductor, it induces an EMF in the conductor. Since the conductor provides a closed path, current can flow through it. This Eddy current produced generates its magnetic field which is equal in magnitude and polarity to the permanent magnet's field and thus opposes it. By rotating an array of permanent magnets above an Aluminum sheet, this principle can be used to create a repulsive force that balances the weight of the spacecraft simulator itself.

Through this paper, the complete dynamical model is developed for the MagLev based Spacecraft Simulator. A special arrangement, known as the Halbach array is employed which increases the strength of the magnetic field at the sheet-facing side. By placing multiple discs under the spacecraft platform, the overall weight of the spacecraft is shared by each. The interactions of the magnetic fields with the Aluminium sheet and the resultant force, in the designed platform, are studied and optimized using magnetic field simulation software. The optimized platform is built and tested extensively to validate theoretical predictions. Finally, the platform is transformed into a complete spacecraft that can be used for research in Rendezvous and Docking control problems.