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HIGH TEMPERATURE SUPERCONDUCTORS: ENABLING TECHNOLOGY FOR NEXT GENERATION SPACE SYSTEMS

Abstract

High temperature superconductors enable ultra-high magnetic field strength and compact electromagnets with reduced cooling requirements, that are increasingly used in a wide range of terrestrial applications. Superconducting electromagnets have the potential to enhance many different space applications, including contact and non-contact mechanisms for active debris removal, magnetic attitude control, vibration isolation, plasma propulsion of various forms, and propellantless propulsion.

For any application to benefit from stable high temperature superconductivity, interfacing to other spacecraft systems needs careful consideration. The challenge is fundamentally one of power and thermal management, notably, thermal control both to lower the superconducting magnet to below its critical temperature and maintaining this state once current flows. Also physical mounting to address magnetic stresses and thermomechanical loads, magnetic field effects on surrounding spacecraft systems, and low resistance electrical connectivity to non superconducting current carrying wires must be addressed. These collectively pose a significant systems integration challenge, and is why, despite their disruptive potential, no high temperature superconducting magnet has ever been operated in space.

This paper describes ongoing testing and systems engineering of a small high temperature superconducting magnet manufactured by Tokamak Energy UK, which is being engineered into a flight experiment targeting a small satellite based mission demonstration. The experiment has specific targets for envelope, budget and schedule to be delivered to orbit and achieve a world first operational test of such a magnet, we are aiming to host this on an In-Space Missions platform. We report on the knowledge transferred from the manufacturer Tokamak Energy, and the readily available UK supply chain providing a small cryocooler, magnetic sensors, high performance passive thermal insulation, and superconducting power transfer cables, synthesised in an update on progress towards the first flight experiment. We further discuss the ongoing systems evaluation of high temperature superconductors and their enabling potential for a range of future space applications.