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THERMAL CONTROL DESIGN FOR HYBRID POWER SUBSYSTEM OF LUNAR ROVER OPERATING AT THE SOUTH POLE

Abstract

The exploration of the moon and its surface has emerged as a top priority for numerous space agencies, driven by the scientific and strategic significance of lunar missions. Rovers play a crucial role in lunar exploration, providing the necessary mobility to navigate and conduct experiments across the lunar terrain. One of the key challenges faced by lunar rovers is the dynamic thermal environment, fluctuating between extreme temperatures from day to night and transitioning between illuminated and shaded regions. The efficient operation of the Electrical Power Subsystem (EPS) is critical for the success of lunar rovers, making it imperative to address the complexities of thermal management. This study is part of a project funded by ESA called “Power management conditioning for hybrid radioisotope-solar power systems”. The work presented here focuses on the conceptual design considerations and the thermal control strategies for a hybrid EPS, incorporating solar panels, batteries, and a Radioisotope Thermoelectric Generator (RTG). This hybrid configuration ensures a reliable and continuous power supply to the rover under diverse lunar scenarios. The research emphasizes the significance of thermal analysis and control design in the sizing of a lunar rover and its EPS. By presenting various conceptual design options and proposing a tailored thermal control solution, the study focuses on a rover intended for operations at the moon’s South Pole, where unique cold environmental conditions pose specific challenges. The sizing process is undertaken along with a study of the optimal relative placement of electrical components, as well as exploring various thermal control options to ensure that all components operate under their optimal

temperature conditions. Thermal analyses are conducted in ESATAN, enabling an accurate geometric representation of the lunar environment and the rover. Subsequently, two models are developed in Python and EcoSimpro to examine the static and dynamic thermo-electric behavior of the hybrid EPS. The findings presented in this work offer valuable insights for the development of future lunar rovers, providing a foundation for the advancement of space exploration missions in the quest for a deeper understanding of our celestial neighbor.