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Space Power Systems for Ambitious Missions (4)

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LUNAR WIRELESS POWER TRANSMISSION: KEY SUBSYSTEMS FOR A CONSTELLATION OF LASER ENERGY-TRANSMITTING SATELLITES.

Abstract

This study delves into the concept of wireless power transmission (WPT) from lunar orbit to the lunar surface. The proposal entails deploying a constellation of satellites orbiting the Moon, tasked with continuous collection of solar energy, which is then transmitted to the lunar surface via electromagnetic waves, notably laser emission. One of the primary challenges facing future lunar bases and all missions involving the Moon is the requirement for significant energy resources to support exploration activities, mining operations, and sustain human life. Traditional solar panel solutions prove inefficient in the unique and challenging lunar environment, prompting the emergence of alternative approaches. This study conducts fundamental sizing analysis of satellites in lunar orbit designed for power transmission towards the lunar surface, with a particular emphasis on the essential subsystems. Special attention is then placed on the development of a receiver optimized for minimum mass and conversion efficiency, strategically positioned at key locations on the lunar surface. Regarding the satellite, alongside fundamental sizing considerations, the study focuses on devising an efficient attitude control system capable of providing precise pointing accuracies with the implementation of a Fine Steering Mirror in a secondary phase, facilitating the precise direction of high-power laser beams. The proposed receiver aims to improve efficiency by receiving laser beams through an optimized geometric architecture. The satellite constellation is arranged in a predetermined stable orbit, which requires precise GNC to maintain position and orientation. Satellite geometries and inertias are defined to ensure accurate control. The analysis also evaluates the requirements of the GNC system under simulated operating conditions, especially considering disturbances due to solar pressure, given the huge area occupied by the solar panels. Finally, the satellite study includes the pre-design of the payload, a high-power fiber laser maximizing its efficiency in the lunar space environment, and its integration with the receiver for power transmission. Requirements for the design of the laser payload are discussed and the total efficiency of the power transmission system is analyzed.