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SPACE POWER SYMPOSIUM (C3)
Technologies and Experiments related to Wireless Power Transmission (2)

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LESSONS ON WIRELESS POWER TRANSMISSION FROM A STUDENT SPACE ELEVATOR

Abstract

Among other applications, Wireless Power Transmission (WPT) is a key requirement for space elevators. Canadian students with the University of Saskatchewan Space Design Team (USST) designed and built a working WPT system for their climber in the Elevator:2010 competition, a NASA Centennial Challenge. Using their system, the USST successfully recovered 1 kW of usable electric power at a distance of 800 m from an 8 kW fibre laser source. Through design, operation, and development of their system, the USST learned key lessons on efficiency, safety, and system scalability. By sharing these lessons, we hope to advance the study and application of wireless power transmission.

EFFICIENCY

Through simulation and experimentation, the USST identified focus areas to maximize efficiency. To combat the inherent temperature-efficiency relationship of PV cells, our panel employed an innovative heatsink for optimum air cooling. PV cells in a given string are limited by their least-illuminated member; this led us to create strings of series cells in concentric circles, providing each cell in a string equal exposure to the radially-symmetric incident beam. Variation of the incident light available is an unavoidable fact when doing long-range, dynamic power beaming; therefore, we had to track the photovoltaic Maximum Power Point to ensure optimal power transfer.

SAFETY

Safety is vitally important when dealing with a laser source capable of direct burns and indirect blinding. Our laser enclosure was designed for direct operator safety, with physical separation from all lasing activities. Direct beam safety was achieved by working closely with aviation and satellite agencies to ensure clear airspace for lasing. Primary reflections off the panel were addressed by simulating and observing the panel on its tether and ensuring a sufficiently large zone of exclusion. Secondary reflections were diffuse and determined to be at safe levels.

SCALABILITY

The dynamic optical control of our beam shape and our GPS-based tracking capabilities are fully scalable. However, the dissipation of the intense thermal load remains an issue. Our design relies heavily on convective air cooling which will not be present in the vacuum of space. In addition, the effects of the atmosphere (absorption, refraction, and scattering) on the beam must be dealt with; the 800 m tests referenced above were performed in 40C desert-floor conditions and showed significant refractive distortion when compared to a 200 m test under similar conditions.