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CLOSED-LOOP OPTICAL TARGET TRACKING FOR LASER POWER TRANSMISSION

Abstract

Over the last years, free-space laser communications were developed rapidly and optical links heavily tested on the ground, between a satellites and a ground station as well as between satellites. Compared to their microwave counterpart, a more precise directional control is necessary due to the small divergence of the laser beam. This is usually realized by an open loop tracking using the directional information of an incident beacon beam. For power transmission however, open loop tracking is not sufficient since the entire beam spot must be placed precisely on the target's receiving area. In the past, a system with closed loop tracking that used spatial beam modulation was realized and reflected light processed to keep the beam on its target. In this paper, a new method is proposed which makes beam modulation dispensable. Instead, it employs a high reflective phase conjugate mirror (PCM) as its key element for target tracking and auto-focusing on the transmitter. Closed loop tracking is achieved by a corner-cube reflector (CCR) which is placed in the middle of the receiving area on the target to form a cavity together with the PCM. For transmitting power, the CCR's aperture has to be made smaller than the diffraction limited spot size of the transmitted laser beam on the receiver. In that way, light that falls onto the CCR is reflected back to the receiver whereas the rest of the incident laser light is converted into useable electric energy by photovoltaic cells that are placed around the CCR. In the experimental part of the paper, a phase conjugate mirror with reflectivity of about R=100 was realized using an optical amplifier and a photorefractive self-pumped phase conjugator. Simulation results show that a reflectivity of R>1000 can be obtained by realizing a phase conjugate mirror of a more efficient type. That can lead to a link-efficiency of η>90%. As a next step, the proposed optical cavity will be realized. A scenario is described where the proposed optical system can be applied to transmit power from a station to a planetary rover which can be remotely powered by the proposed system. With a few modifications it is supposed to be applicable to a link from a satellite down to the earth. On earth, recently proposed solar power generating structures on high-altitudes are considered to receive the power above the clouds.