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EXPERIMENTAL VERIFICATION OF POINTING AND TRACKING SYSTEM OF OPTICAL COMMUNICATION TERMINAL FOR SMALL SATELLITES

Abstract

Small satellites have been increasingly exploited in the last years for a variety of educational, scientific and commercial applications, leveraging their low cost due to reduced size and mass. In particular, several constellations in LEO based on small satellites are under development for applications such as Earth imaging, global connectivity and data relay. The capability to transmit large amount of data both in satellite-to-ground and satellite-to-satellite scenarios plays a key role in the performance and profitability of such spaceborne infrastructures.

Optical communication is an emerging technology that may dramatically increase the telecom capabilities of small satellites. In fact, the use of optical or near-infrared wavelengths results in very narrow beams that can deliver high-speed, point-to-point data transmission with compact devices, especially if compared to their radio counterparts. However, the increased directivity of transmit beams poses severe requirements on the pointing accuracy of the optical antenna, which must be a fraction of the laser beamwidth and is typically not compatible with the performance of attitude determination and control subsystems of small satellites. For this reason, dedicated pointing and tracking systems are necessary to establish mutual tracking between two terminals, both in space-to-ground and in intersatellite-link scenarios.

In this paper, the experimental verification of the pointing and tracking system of the proto-flight model of an optical communication terminal for small satellites is presented. The terminal, called LaserCube, fits in two CubeSat units and is conceived to operate onboard spacecraft starting from the 6U form factor, and larger. The terminal is provided with a dual stage pointing system, composed by a coarse pointing mechanism used to orient the optical head and a fast-steering mirror for fine pointing of receive and transmit lasers. The coarse pointing mechanism is based on the parallel platform configuration and alone can provide 50 μrad rms pointing accuracy when operating in conjunction with a beacon laser used for feedback. The dual stage control algorithm operates the two pointing stages synergically, targeting an overall pointing accuracy of 10 μrad rms while rejecting the disturbances coming from the satellite bus.

The pointing system of the LaserCube proto-flight model has been experimentally verified in laboratory conditions that replicate real operational scenarios in space for what concerns beacon signal attenuation due to distance and the disturbances generated by the host satellite. A dedicated setup was used to directly measure the pointing error and asses the system performance.