National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Communications

Fine-pointing Optical Communication System Using Laser Arrays

Space optical data transmission from satellites using laser arrays to provide fine pointing capability

NASA Ames has developed a novel system in its portfolio for optical data transmissions from satellites using laser arrays for laser beam pointing. It is a fine pointing capability for laser beam pointing to augment body pointing by CubeSats in Low Orbit Earth (LEO). It is simple, static and compact. It combines a small lens system and a vertical-cavity surface-emitting laser (VCSEL)/Photodetector Array in a novel way for laser beam pointing. Body pointing was used earlier for CubeSats in LEO in NASA's Optical Communications and Sensors Demonstration (OCSD) program [1]. This fine pointing capability was computer simulated for the CubeSats used in the OCSD program [2,3]. With fine pointing, the spot size on the Earth was reduced by a factor of eight with a reduction in laser output power by a factor of sixty-four, thereby mitigating the thermal load challenge on the OCSD CubeSats.

BENEFITS

- Simple, static, compact, accurate pointing
- Low size, weight, and power (SWaP)
- Fine pointing capability could also be used for CubeSats in LLO (Low Lunar Orbit) [4]
- Nanosecond reaction time scale for pointing changes

THE TECHNOLOGY

A new method is described for optical data transmissions from satellites using laser arrays for fine pointing of laser beams that use body pointing. It combines a small lens system and a VCSEL/Photodetector Array in a novel way to provide a fine pointing capability for laser beams that are pointed by body pointing of a CubeSat. As Fig. 1 shows, an incoming laser beam (green or blue, with rightward arrows), transmitted from a ground terminal, enters the lens system, which directs it to an element of the pixel array (gray rectangle). Each element, or pixel, consists of a VCSEL component/photodetector pair. The photodetector detects the incoming beam, and the VCSEL component returns a modulated beam to the lens system (green or blue, with leftward arrows), which sends it to the ground terminal. As the incoming beam changes direction, e.g., from the blue to the green incoming direction, this change is detected by the adjacent photodetector, and the laser paired with that photodetector is turned on to keep the outgoing laser beam on target. The laser beams overlap so that the returning beam continues to point at the ground terminal. The VCSEL component may consist of a single VCSEL or a cluster of VCSELs. Figure 2 shows the propagation of two overlapping laser beams. The system can very accurately point finely focused diffraction-limited laser beams. Also, simultaneous optical multiple access (OMA) is possible from different transceivers within the area covered by the laser array. For this electro-optical system, reaction times to pointing changes and vibrations are on the nanosecond time scale, much faster than mechanical fine pointing systems.

Fig. 1

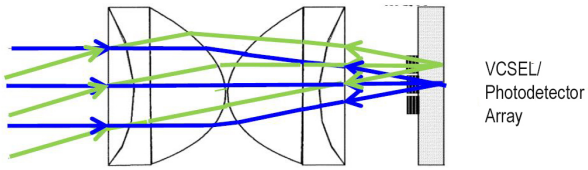

Fig. 2

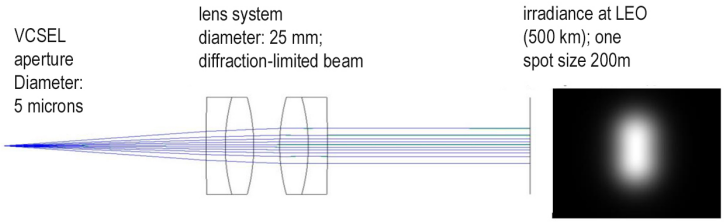

Fig.1: Space Coptical Communications using a Lens System with a VCSEL/Photodetector Array
Fig. 2: Propagation of two overlapping laser beams

APPLICATIONS

The technology has several potential applications:

- CubeSat communications
  - CubeSats in Low Earth Orbit (LEO)
  - Artemis Program, CubeSats in Low Lunar Orbit (LLO)
- Spacecraft industry
- Space communication:
  - Optical multiple access (OMA)

PUBLICATIONS

Patent No: 11,159,247; 9,774,395; 9,954,613

[1] T.S. Rose et al., "Optical communications downlink from a 1.5U CubeSat: OCSD program", Free-Space Laser Communications XXXI, SPIE Photonics West 2019, San Francisco, CA, February 2019.

[2] Goorjian, P. M., "A New Laser Beam Pointing Method Using Laser Arrays", Free-Space Laser Communications XXXI, SPIE Photonics West 2019, San Francisco, CA, February 2019.

[3] Goorjian, P. M., "Free-Space Optical Communication for Spacecraft and Satellites, including CubeSats in Low Earth Orbit (LEO)", OSA Advanced Photonics Congress, July 2019.

[4] Goorjian, P. M., "Free-Space Optical Communication for CubeSats in Low Lunar Orbit (LLO)", Free-Space Laser Communications XXXII, SPIE Photonics West 2020, San Francisco, CA, February 2020.

More Information

National Aeronautics and Space Administration

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