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Free Space Laser Communications Systems

Abstract

Free space laser communications systems are wireless data links through the atmosphere and space. They work only under clear line-of-sight conditions between each unit, but they eliminate the need for securing right of ways, buried cable installations and no government licensing is necessary. Free space laser communications systems can be quickly deployed since they are small and do not need any radio interference calculations. Additionally, no spectrum fees have to be paid.

This document gives a brief description about the principle of operation, applications and their advantages and disadvantages.

1. Operation

Free space laser communications systems are wireless connections through the atmosphere and space. They work similar to fiber optic cable systems except the beam is transmitted through open space. The carrier used for the transmission of this signal is generated by either a high power LED or a laser diode. The laser systems operate in the near infrared region of the spectrum. The laser light across the link is at a wavelength of 750 to 1600 nm. Usually two parallel beams are used, one for transmission and one for reception.

Figure 1: MAGNUM 45 High-Speed Laser-Communication System (Source: LSA Photonics)

2. Applications

2.1 Applications in the atmosphere

Depending on the requested link availability and the climatic zone where the free space laser communications systems are used, the link can span distances up to 7 km at low bitrates or provide bitrates up to 10 Gbps at shorter distances. The systems are protocol transparent allowing transmission of digital computer data (LAN interconnect), video, voice over IP, multiplexed data, or ATM. They are suitable for temporary connectivity needs such as at conventions, sporting events, corporate and university campuses, disaster scenes or military operations.

2.2 Applications in space

The link can span distances of several thousand kilometers in space, such as for communication between satellites (intersatellite links).

2.3 Applications in the space and in the atmosphere

Space-to-ground laser communication has been established sucessfully [4].

3. Advantages and Disadvantages

Free space laser communications links eliminate the need for securing right of ways, and buried cable installations. As the equipments operate within the near infrared spectrum, they are not subject to government licensing and no spectrum fees have to be paid (according to Art. 7 in [4] requires only the use of the frequency spectrum below 3’000 GHz a licence). Additionally, since no radio interference studies are necessary, the systems are quickly deployable. The narrow laser beamwidth precludes interference with other communication systems of this type.

Free space laser communications systems provide only interconnection between points that have direct line-of-sight. They can transmit through glass, however, for each glass surface the light intensity is reduced, due to a mixture of absorption and refraction, thus reducing the operational distance of a system. Occasionally, short interruptions or unavailability events lasting from some hours up to a few days can occur.

4. Security Aspects

Free space laser communications systems have narrow optical beam paths, which are not accessible unless viewing directly into the transmitter path. Any potential eavesdropping will result in an interruption of the data transmission. The existence of laser beams cannot be detected with spectrum analyzers.

5. Safety Aspects

The free space laser communications systems do not require certification for handling or operation. Although the emitted laser beam is invisible to the unaided eye, it can cause eye damage if viewed directly at close range for extended periods of time (further details can be found in [1], [3] and [5]).

6. Further remarks for free space laser in the atmosphere

Microwave systems have the ability to achieve a high link quality (error performance and availability) for distances of up to 100 km. Measurements on a 600 m first generation free space laser communications link carried out by Swiss Telecom in the area of Berne, showed a significant lower quality. The degradation effects can be categorized as follows:

- propagation effects and
- mechanical insufficiencies.

The origin of the first category is quite obvious, e.g.: if heavy fog, snow or smoke blocks the line-of-sight between the units or the sun is interfering the laser beam. Unfortunately, there are not many countermeasures to improve the situation in such cases. The source for the second category can be found in the narrow optical beam. Therewith the link performance is sensitive to vibration, wind sway, and thermal expansion of the equipment.

Last but not least it should be noted, that a microwave link designer has – within limits - the possibility to reduce the influence of the propagation effects and to optimize the desired link quality and its costs by choosing the frequency, antenna diameters, diversity protection, etc. A free space laser communication system has to be taken as it is.

Annex

i. References

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