FREE SPACE OPTICS (FSO)

Definition

Free Space Optics (FSO) is an optical communication technology that uses light propagating in free space to transmit data between two points.

Basics

In telecommunications, **Free Space Optics (FSO)** is an optical communication technology that uses light propagating in free space to transmit data between two points. The technology is useful where the physical connections by the means of fibre optic cables are impractical due to high costs or other considerations.

History

Optical communications, in various forms, have been used for thousands of years. The Ancient Greeks polished their shields to send signals during battle. In the modern era, semaphores and wireless solar telegraphs called heliographs were developed, using coded signals to communicate with their recipients.

In 1880 Alexander Graham Bell and his assistant Charles Sumner Tainter created the photophone, which Bell considered his most important invention. The device allowed for the transmission of sound on a beam of light. On June 3, 1880, Bell conducted the world's first wireless telephone transmission between two building rooftops.

The invention of lasers in the 1960s revolutionized free space optics. Military organizations were particularly interested and boosted their development. However the technology lost market momentum when the installation of optical fiber networks for civilian uses was at its peak.

Usage and technologies

Free Space Optics are additionally used for communications between spacecraft. The optical links can be implemented using infrared laser light, although low-data-rate communication over short distances is possible using LEDs. Maximum range for terrestrial links is in the order of 2-3 km, but the stability and quality of the link is highly dependent on atmospheric factors such as rain, fog, dust and heat. Amateur radio operators have achieved significantly farther distances (173 miles in at least one occasion) using incoherent sources of light from high-intensity LEDs. However, the low-grade equipment used limited bandwidths to about 4kHz.

In outer space, the communication range of free-space optical communication is currently in the order of several thousand kilometers, but has the potential to bridge interplanetary distances of millions of kilometers, using optical telescopes as beam expanders. IrDA is also a very simple form of free-space optical communications.

Secure free-space optical communications have been proposed using a laser N-slit interferometer where the laser signal takes the form of an interferometric pattern. Any attempt to intercept the signal causes the collapse of the interferometric pattern. Although this method has been demonstrated at laboratory distances in principle it could be applied over large distances in space.

Applications

Two solar-powered satellites communicating optically in space via lasers.Typically scenarios for use are:

- LAN-to-LAN connections on campuses at Fast Ethernet or Gigabit Ethernet speeds.
- LAN-to-LAN connections in a city. example, Metropolitan area network.
- To cross a public road or other barriers which the sender and receiver do not own.
- Speedy service delivery of high-bandwidth access to optical fiber networks.

- Converged Voice-Data-Connection.
- Temporary network installation (for events or other purposes).
- Reestablish high-speed connection quickly (disaster recovery).
- As an alternative or upgrade add-on to existing wireless technologies.
- As a safety add-on for important fiber connections (redundancy).
- For communications between spacecraft, including elements of a satellite constellation.
- For inter- and intra-chip communication.

The light beam can be very narrow, which makes FSO hard to intercept, improving security. In any case, it is comparatively easy to encrypt any data traveling across the FSO connection for additional security. FSO provides vastly improved EMI behavior using light instead of microwaves.

How it Works

FlightStrata Illustration FSO technology is surprisingly simple. It's based on connectivity between FSO-based optical wireless units, each consisting of an optical transceiver with a transmitter and a receiver to provide full-duplex (bi-directional) capability.

Each optical wireless unit uses an optical source, plus a lens or telescope that transmits light through the atmosphere to another lens receiving the information. At this point, the receiving lens or telescope connects to a high-sensitivity receiver via optical fiber.

This FSO technology approach has a number of advantages:

- Requires no RF spectrum licensing.
- Is easily upgradeable, and its open interfaces support equipment from a variety of vendors, which helps enterprises and service providers protect their investment in embedded telecommunications infrastructures.
- Requires no security software upgrades.
- Is immune to radio frequency interference or saturation.
- Can be deployed behind windows, eliminating the need for costly rooftop rights.

Advantages

- License-free operation
- High bit rates
- Low bit error rates
- Immunity to electromagnetic interference
- Full duplex operation
- Protocol transparency
- Very secure due to the high directionality and narrowness of the beam(s)
- No Fresnel zone necessary

Disadvantages

For terrestrial applications, the principal limiting factors are:

- Beam dispersion
- Atmospheric absorption
- Rain
- Fog (10..~100 dB/km attenuation)
- Snow
- Scintillation
- Background light

- Shadowing
- Pointing stability in wind
- Pollution / smog
- If the sun goes exactly behind the transmitter, it can swamp the signal.

These factors cause an attenuated receiver signal and lead to higher bit error ratio (BER). To overcome these issues, vendors found some solutions, like multi-beam or multi-path architectures, which use more than one sender and more than one receiver. Some state-of-the-art devices also have larger fade margin (extra power, reserved for rain, smog, fog). To keep an eye-safe environment, good FSO systems have a limited laser power density and support laser classes 1 or 1M. Atmospheric and fog attenuation, which are exponential in nature, limit practical range of FSO devices to several kilometres.

Source: http://www.juliantrubin.com/encyclopedia/electronics/fso.html