COMPARISON OF DIFFERENT TRANSMITTERS USING 1550NM AND 10000NM IN FSO COMMUNICATION SYSTEMS

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ABSTRACT

In the recent past Free Space Optical (FSO) communication has taken over the radio frequency communication and microwave systems due to its advantages like its long-range operations devoid of need of license. In this paper we will find the most efficient transmitter suitable for free space optical (FSO) communication. The theoretical analysis of behaviour of an FSO wireless communications system is done using on off keying with different transmitters over fog weather conditions. Based on different models for optical beam propagation at 1550nm and 10000nm on an FSO, the bit error rate (BER) and Q-factor under fog weather are analyzed.

KEYWORDS

Free Space Optics; Bit Error Rate; Q-factor; Turbulence.

1. INTRODUCTION

Free space means air, vacuum and outer space. Free-space optical communication (FSO) is an optical communication technology which uses light, propagating in free space to transmit data wirelessly for telecommunications. It is point to point infrared spectrum based optical communication between optical transceivers that are separated by physical medium known as air [1]. It has evolved as a future technology for coming generation indoor and outdoor broadband wireless applications. Indoor wireless optical communication is also called wireless infrared communication; outdoor optical wireless communication is commonly called FSO. FSO communication involves direct Line Of Sight and point-to-point laser links from transmitter to receiver via atmosphere [2]. There are numerous benefits of free space optics: lower costs associated with the system, no fibre cable required, no rooftop installations required and no license is required. Transmission rate of this system is very high i.e. around 1.25 GB per second, hence can transmit a large amount of data. In future it is expected that it will increase to 10 GB per second .This speed is due to the fact that the signals can be transmitted through the air faster than they can be transmitted through fibre optic cables. Interference between signal and radio frequencies is negligible [3]. The FSO technology is line of sight (LOS) link based technology which uses a small divergence angle laser or LED as transmitter and receiver whose field of view (FOV) is very narrow to communicate data between two points. FSO is a cheaper option compared to the fibre optics and RF systems because it offers a bandwidth which is similar to that of optical fibre at a low cost and much ease of deployment. The features of FSO systems such as unregulated spectrum, fast deployment, light weight and a secure communication, make it very

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attractive for commercial uses [4]. But it also has certain limitations as reliability of an FSO communication system is greatly affected by the atmospheric conditions through which it has to propagate. Aerosol, fog, gases, rain and various other suspended particles in the atmosphere causes the optical beam scattering and absorption which results in a large path loss and as a consequence limiting the link length to less than 100m [5, 6, 7].Even in clear sky conditions atmospheric turbulence, which are caused by temperature and pressure inhomogeneity's present in the atmosphere, leads to refractive index fluctuations in atmospheric layers. When signal propagate through such turbulent atmospheric layers, it will experience random fluctuations. The variations in the amplitude and phase of the received signal due to atmospheric turbulence effect are known as scintillation. Scintillation causes deep signal fading that lead to increased bit error rate and hence degrades the link performance especially for link ranges greater than 1km [7]. The consequence of scintillation is more critical for small aperture receivers [5, 8].

2. ATMOSPHERIC TURBULENCE

Perhaps most important difference between Fiber Optics and FSO is that FSO is affected by prevailing conditions of environment [9]

A. Thick fog is one of the most complex forms of interference in free space optical communication. This occurs because of the moisture in the fog that can reflect, absorb, and scatter the signal.
B. Absorption and scattering both occur when there is a lot of moisture in air. Absorption of the signal causes a reduction in signal strength. Scattering causes the signal to be dispersed in various directions. This is an issue particularly for long distances.
C. Physical obstructions, such as trees and even building, can also be a problem.
D. Scintillation, is heat rising from the earth or man-made, can also disrupt in the signal.
E. Alignment, the main challenge with FSO systems is maintaining transceiver alignment. FSO transceiver transmits highly directional and narrow beams of light.

When an optical beam propagates in atmosphere, it experiences different refractive indices in its path which causes random variation in its intensity and phase that results in the signal fading [9]. Each of these conditions are explained below.

Fog Condition: Fog is the most pivotal weather phenomenon with respect to FSO as it consists of small water droplets with radii nearly the size of infrared wavelengths. The particle size distribution varies according to different levels of fog. Weather condition is referred to as fog when visibility range lies between 0–2,000 meters. Sometimes it is difficult to describe foggy conditions using physical methods, therefore expressive words such as "advection fog" or "convection fog" are used to characterize the nature of fog [10].

Snow Condition: Snowflakes are ice crystals that come in a variety of sizes and shapes. Whiteout conditions might attenuate the beam, but this problem for FSO systems can be coped with as the size of snowflakes is large in comparison to the operating wavelength [11]. The amount of attenuation in snow condition is 3 dB/km to 30 dB/km[6]

Rain Condition: Rain has a distance-reducing impact on FSO, but still its influence is significantly less than that of other weather conditions. The influence is due to large difference between the radius of raindrops and the wavelength of typical FSO light sources [12]. Typical rain attenuation values are reasonable in nature.

Clear Weather Condition: When there is a clear weather; there is very less attenuation. The attenuation factor value in the clear weather ranges from 0 to 3 dB/km [13].

Table 1 shows the different weather conditions with their attenuations

Condition	Attenuation in dB/km
Heavy Fog	80-200
Light Fog	40-70
Snow	20-30
Rain	4-17
Clear Weather	0.2-3

2.1. Optical Wavelengths

Most of the available FSO systems for commercial use operate in the near-IR wavelength range lying from 750 and 1600 nm, with some systems being developed to operate at the IR wavelength of 10,000 nm. But there are numerous factors according to which a given design team takes the decision of wavelength to be chosen [14].

2.1.1. 1520-1600 nm

These wavelengths are well suited for free-space transmission with high-quality transmissions and its detector components are readily available. It has several drawbacks such as high price; detectors being less sensitive and a smaller receiver surface area in comparison to silicon APD detectors which operate in the 850-nm wavelength.

2.1.2. 10,000 nm (10 microns)

The claims of better fog transmission have resulted in its commercial use with new components being developed because there are very few components available at 10 microns for use. Also, 10-micron energy does not penetrate glass hence it is ill-suited to behind-window deployments. However, the poor glass penetration means it is highly unlikely to be concentrated by optical aids, thus allowing for high-power operation in unrestricted environments.

3. DIFFERENT TRANSMITTERS

3.1. Led

These have advantages over traditional UHF RF-based systems from improved isolation between systems, the cost and size of receivers/transmitters, Government licensing laws and by combining space lighting and communication into the same system. Lasers sources make transmission possible at high data rates when compared to fiber communication networks.

3.2. Laser

There are several advantages of semiconductor lasers for free space optics (FSO) compared to LEDs: high optical output, better optical spectrum, advantages for beam shaping. There are several atmospheric transmission windows and high quality semiconductor lasers with a suitable wavelength for these windows are available.

3.3. Laser Safety

Laser safety is a seminal issue. The basic safety concern is the exposure of the eye or skin to the laser. High-power beams can cause injury to skin. As the eyes are able to focus light and therefore concentrate optical energy, the risk of injury to eyes is increases. A laser which is considered to be “eye-safe” is automatically taken to be “skin-safe.” Like sunlight, laser light travels in parallel rays that depend upon wavelength thus eye focuses to a point on the retina and layer of cells responds to light. Exposure to a laser beam of sufficient power has similar adverse effect on the eye as staring at the sun can have.

Longer wavelengths present in the IR spectrum have more injurious effect in comparison to the UV and visible radiation of sunlight. Naturally, eye turn away from a bright visible light when light is focused on it. So, eye’s respond in different manner within the range (400 to 1400 nm

4. SYSTEM MODELLING

FSO design has been modelled and simulated for performance characterization by using OptSim5.4. Fig.1 shows a block diagram of FSO communication link. The transmitter consists of a PRBS generator at bit rate 1.25Gbps, modulation driver, and a directly modulated CW Laser/LED at different wavelengths. Optical power used in transmitter is 1.3dBm[10]. The FSO link has a 500m range with beam divergence angle of 3mrad. The APD receiver is followed by a BER tester for determining q factor and BER.

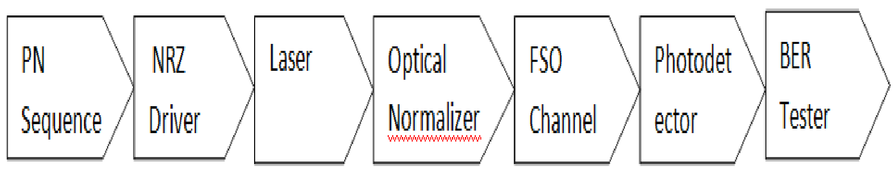


Figure.1. Block Diagram

The FSO compound component is shown in Fig.2. It comprises of optical attenuator block followed by optical noise adder block which is used to add the background radiation to received signal.

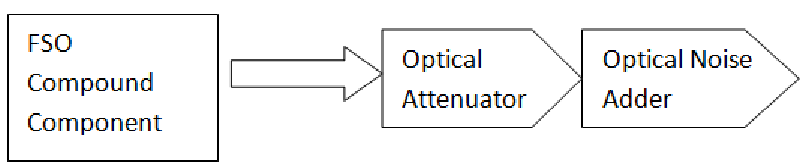


Figure.2. Simulation set-up for the FSO link

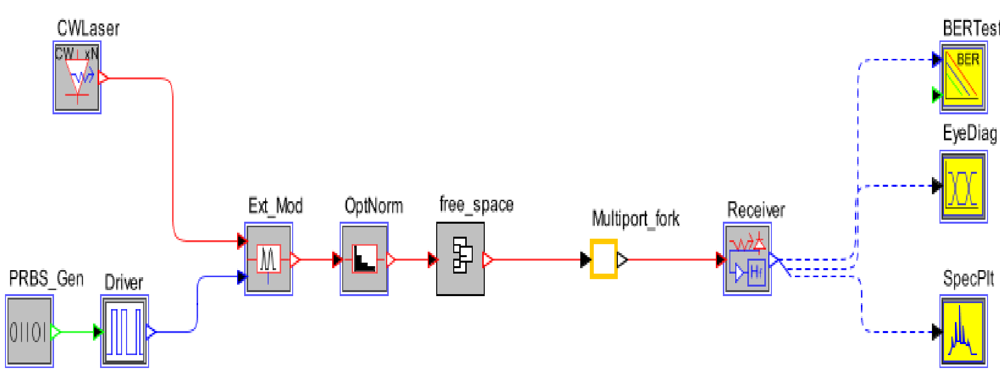
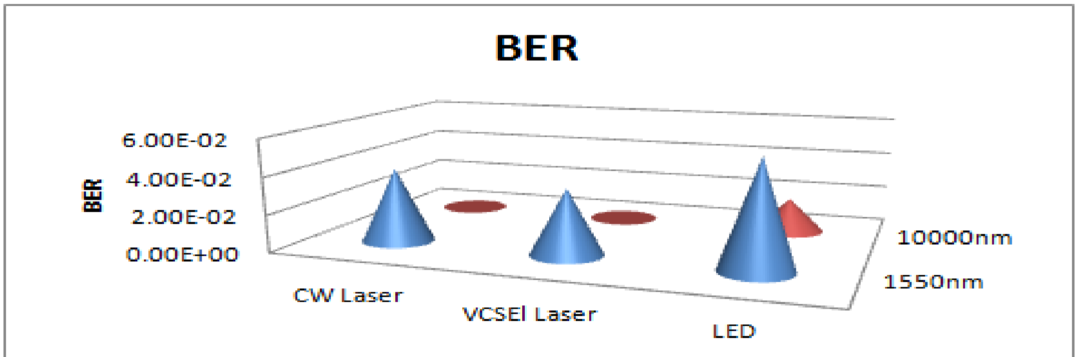


Figure.3. Simulation setup for FSO link

Fig 3 shows simulation set-up for FSO link. It consists of transmitter section, free space channel and receiver section.

5. RESULTS AND DISCUSSION

In this proposed design, performance of different modulation transmitters has been studied in free space optical communication. Here a comparative study has been carried out at different transmitters for free space optical communication. Results have been taken by selecting various parameters such as wavelength (1550nm, 10000nm), transmitter power 1.3dBm, data rate 1.25Gbps, standard deviation (sigma) of 1.9dB, attenuation factor of 40dB/km , divergence angle 3mrad and transmission length 500m.



	CW Laser	VCSEl Laser	LED
1550nm	3.99E-02	3.53E-02	5.72E-02
10000nm	8.31E-45	1.52E-14	1.83E-02

Figure.4. BER Comparison

Fig 4 shows the bit error rate using various transmitters such as CW Laser, VCSEL, LED and at two different wavelengths (1550nm, 10000nm). BER is better at 40 db/km using CW Laser instead of VCSEL laser in case of 10000nm wavelength.

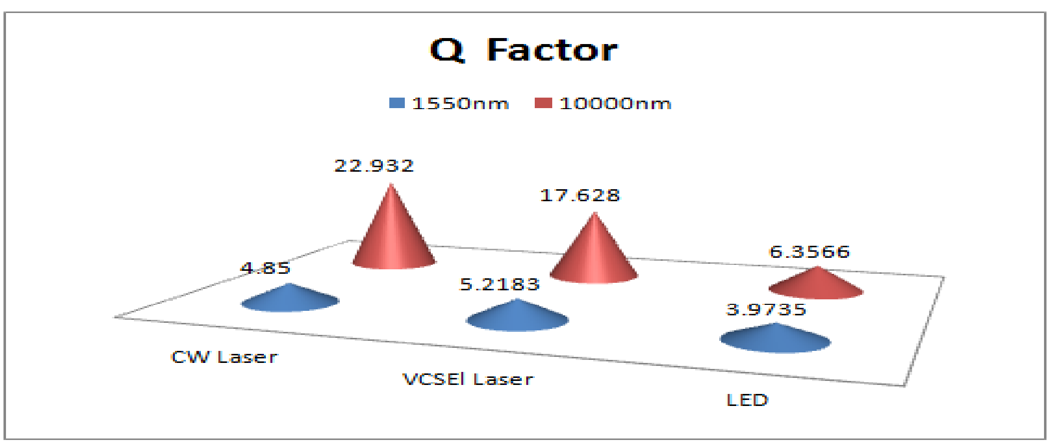


Figure.5.Q-Factor Comparison

Fig 5 shows Q factor using various transmitters such as CW Laser, VCSEL, LED and at two different wavelengths(1550nm,10000nm) . Q-Factor is good at 40db/km using CW Laser in case of 10000nm instead of VCSEL laser.

6. CONCLUSIONS

In this work, FSO communication link is established for 500m length between transmitter and receiver at data rate of 1.25 Gbps. Results show that CW Laser is better in comparison to VCSEL and LED when used at 10000nm wavelength for FSO Communication under foggy conditions (40db/km) on the basis of BER and Q-Factor.

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