Performane Evaluation of High Speed Optical Wireless Communication System

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ABSTRACT

In this paper, performance evaluation of high speed optical wireless communication has been observed. It has been observed that Q value lies in the range of 26 to 15 dB and 25 to 14dB in the transmission power (8dBm) and attenuation (23dB) at distance of 800m to 2000m in free space optical communication. Similarly BER lies in the range of 10^{-96} to 10^{-4} and 10^{-90} to 10^{-4} in the transmission power and attenuation at transmission distance of 800m to 2000m in free space. We have achieved BER of 10^{-9} at 2000 m with data rate 2.50 Gbps in free space optical communication system.

General Terms

FSO Modeling, FSO Analysis, Bit Error Rate.

Keywords

Optical Wireless Communication, Bit Error Rate, Attenuation, Optical Received Power, Transmission Power.

1. INTRODUCTION

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 connection by the means of fiber optic cables is impractical. It is similar to fiber optic communications in that data is transmitted by modulated laser light (low-data-rate communication over short distances is possible using LED) [1]. Instead of containing the pulses of light with in a glass fiber, these are transmitted in a narrow beam through the atmosphere. Light travels through air faster than it does through glass, so it is fair to classify FSO as optical communications at the speed of light. The stability and quality of the link is highly dependent on atmospheric factors such as rain, fog, dust and heat. FSO systems are being considered for military systems because of their inherent benefits as most of the systems are rated for greater than 1 km in three or more lasers operating in parallel to mitigate distance-related issues. The quality of the transmission is characterized by the realized bit-error rate (BER) [2]. Free Space Optics (FSO) also knows as Optical wireless communication is a cast effective and attractive solution for high data rate, image, and voice transmission [3]. It has received significant possible alternative to solve the bottleneck connectivity problem and as an alternative to more conventional RF/microwave links [4]. FSO is less affected by snow and rain, but can be more affected by the atmospheric turbulence and fog.

The attenuation coefficient typically ranges from a few dB/Km in clear atmosphere to 270dB/Km in dance fog region [5]. The three most significant factors that effect the optical transmission are absorption, Scattering and scintillation[6, 8]. All these can reduce the amount of energy received by receiver. Absorption is caused primarily by carbon dioxide and water vapor in the air along the transmission path. Their presence is a function of both humidity and altitude. This causes a decrease in the power density (attenuation) of the FSO beam and directly affects the availability of a system. However, the use of appropriate power based on atmospheric conditions and the use of spatial diversity (multiple beams within a FSO based unit) helps maintain the required level of network availability [9-11].

The transmittance T of laser radiation that has propagate over a distance L is given by the Bear's low

$$T = \exp(-\alpha_e(\lambda).L[Km]) \tag{1}$$

The α_e is the extinction coefficient describes the extinction level of the medium.

Scattering is caused when the wavelength collide with scatter. When the scatter size is comparable size of wavelength this is known as Mie scattering, when the scatter is smaller than the wavelength this is known as Rayleigh scattering [12, 15]. The scattering coefficient βn in clear weather can be expressed according to visibility and wavelength by the following expression [16].

$$\beta_n = \frac{3.91}{V}\left(\frac{\lambda}{550nm}\right)^{-Q} \tag{2}$$

where V is the visibility in km and λnm is the wavelength (in nm), Q is a factor which depends on the scattering particle size distribution [17]:

1.6 for large visibility (V > 50 km), 1.3 for mean visibility (6 < V < 50 km), 0.585 $V^{1/3}$ for low visibility (V < 6 km).

A recent study proposes another expression for the parameter Q [17]. This expression, not yet proven experimentally, is:

Q = 1.6 if V > 50 km, Q = 1.3 if 6 km < V < 50 km, Q = 0.16*V + 0.34 if 1 km < V < 6 km,Q = V − 0.5 if 0.5 km < V < 1 km, Q = 0 if V < 0.5 km.

When molecular and aerosol absorption coefficients as well as the Rayleigh scatter coefficient have low values, the extinction coefficient can be given by the following equation [17]:

$$\alpha \cong \beta_n = \frac{3.91}{V}\left(\frac{\lambda}{550nm}\right)^{-Q} \quad (3)$$

Corresponding atmospheric attenuation is given by following Beer's Law in Equation (4) [14].

$$\tau(R) = \frac{P(R)}{P(O)} = \exp(-\beta_n R) \quad (4)$$

Equation (4) can be converted to logarithms scale as:

$$\tau(R) = -10\log\frac{P(R)}{P(O)} = -10\log e^{(-\beta_n R)} = 10\log e^{(-\beta_n R)} \quad (5)$$

In this work, we have presented the simulation investigation of FSO communication system. At high data rate is not covered in previous research work. The simulation setup description of FSO communication system is represented in section 2 follow by the simulation result discussion in section 3. The overall conclusions drawn from our simulation results are presented in section 4.

2. SYSTEM MODELING

FSO system basic design has modeled and simulated for performance characterization by using OptSim 4.6 which is a powerful software design tool that enables to plan, test and simulate almost every type of optical link in the transmission layer of a broad spectrum of optical networks from LAN, MAN to ultra long haul. It can minimize time requirement and decrease cost related to the design of optical systems, links and even components. There are several parameters of the system varied to obtain the optimum system performance. The main parameter that considered the laser propagation distance between the specific FSO channels. The FSO design model is illustrated in Fig 1.

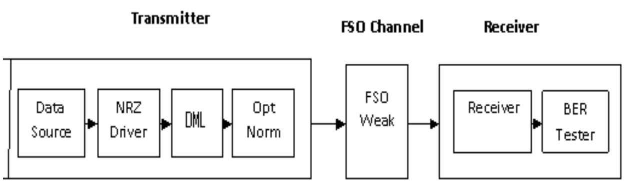


Figure 1. Block diagram of FSO.

In our proposed design, the optical transmitter consists of three subsystems. The first subsystem is the Pseudo-Random Binary Sequence (PRBS) generator. This subsystem is to represent the information or data that wants to be transmitted. The output from a PRBS generator is a bit stream of binary pulses; a sequence of "1"s (ON) or "0"s (OFF), of a known and reproducible pattern. The second subsystem is the Non-Return-to-Zero (NRZ) electrical pulse generator. This subsystem encodes the data from the PRBS generator by using the NRZ encoding technique. A NRZ line code is a binary code in which 1's are represented by one significant condition and 0's are represented by some other significant condition. The third subsystem in the optical transmitter is the direct modulated lasers. Direct modulated lasers based on InGaAs semiconductor technology with operating wavelengths around 1550 nm [7] were developed specifically for fiber optic communications systems because of the low attenuation characteristics of optical fiber in this wavelength range. The free space between transmitters - receiver is considered as FSO channel which is propagation medium for the transmitted light. In this design OptSim 4.6 software used, the FSO channel is between an optical transmitter and optical receiver with aperture diameter of 180cm^2 at each end respectively. Meanwhile, the beam divergence angle is set to 3 mrad. The optical receiver consist of an avalanche photodiode (APD) followed by a front-end amplifier, a low pass filter. The InGaAs APD must be capable of meeting the system bandwidth requirements. Therefore, a Trans-Impedance Amplifier (TIA) is used after the detector because it is preferred for use in wideband optical communication receivers. A Low Pass Filter (LPF) after the front-end amplifier is used to filter out the unwanted higher frequency signals. Bessel LPF is used with a cut-off frequency of 0.75 x bit rate of the signal. The receiver is use to regenerate electrical signal of the original bit sequence and the modulated electrical signal as in the optical transmitter to be used for BER analysis. Table I shows the parameter and their specification taken in to consideration during the simulation.

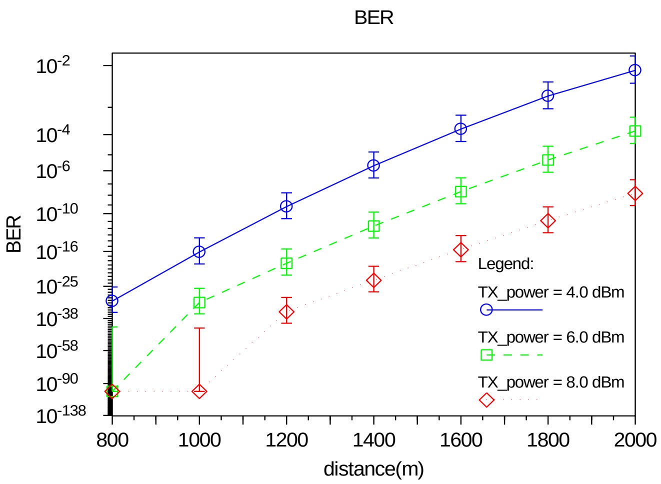
TABLE I

TECHNICAL SPECIFICATION FOR OWC LINK

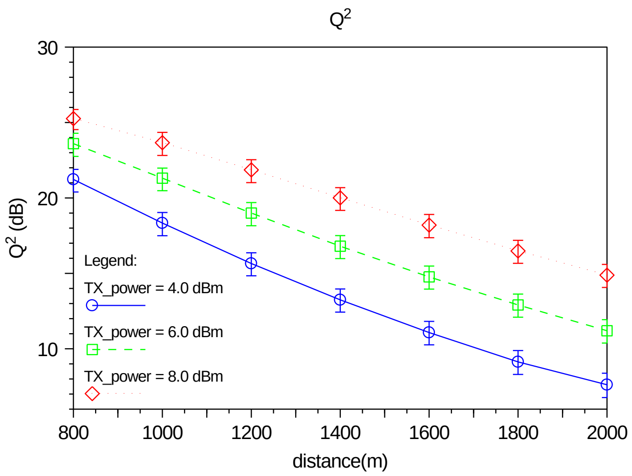
Parameters	**Description/Values**
Transmitter Type	DMLaser
Tx Wavelength	1550nm
Transmitter optical power	8dBm
Tx aperture area	180cm^2
Link distance	1500 meter
PD/APD Multiplier	1.0
Data rate	2.50Gbps
APD Quantum Efficiency	0.8
Filter Type	LPBessel
APD Dark Current	1µA
Sigma Add	1.9
Divergence Angle	3mrad

3. RESULT ANALYSIS

In our proposed design, by varying the transmission power, attenuation of the free space optical communication system and the transmission distance between the two transceivers, the system performance in terms of BER and Q factor has obtained by using laser Wavelength of 1550 nm.



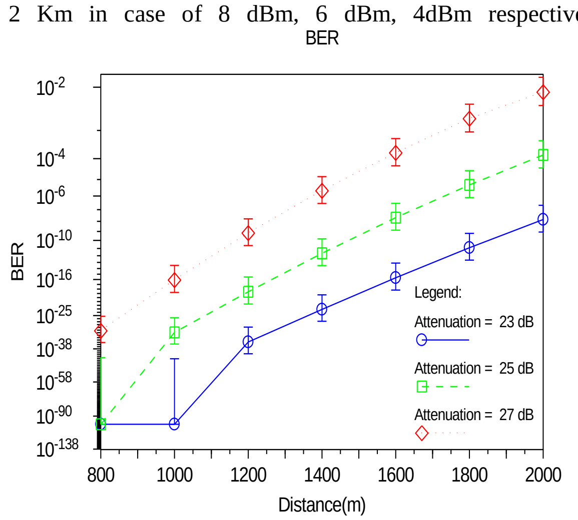
(a)



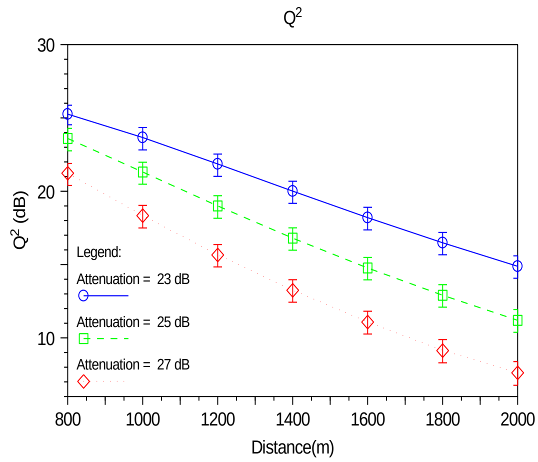
(b)

Figure 2.(a) and (b) BER and Q factor for variable length at different transmission distances

Fig. 2(a) and 2(b) indicated the graph between BER and the Q value various the transmission distance at different transmission power, from result it has been observed that there is significant increase in the Q value which lies within [26, 24, 22] to [15, 11, 8], for transmission distance of 2 Km in case of 8 dBm, 6 dBm, 4dBm respectively and in the BER case , it observe that there increase in BER is lies within [10^{-110}, 10^{-96}, 10^{-32}] to [10^{-9}, 10^{-4}, 10^{-2}] for transmission distance of 2 Km in case of 8 dBm, 6 dBm, 4dBm respectively.



(a)



(b)

Figure 3. (a) and (b) BER and Q factor for variable length at different attenuations.

Fig. 3(a) and 3(b) indicated the graph between BER and the Q value various the transmission distance at different attenuation, from result it has been observed that there is significant increase in the value of Q value which lies within [25, 24, 22] to [14, 11, 8], for transmission distance of 2 Km in case of 23 dB/Km, 25dB/Km, 27dB/Km respectively and in the BER case , it observe that there increase in BER is lies within [10^{-95}, 10^{-90}, 10^{-32}] to [10^{-9}, 10^{-4}, 10^{-2}] for transmission distance of 2 Km in case of 23 dB/Km, 25dB/Km, 27dB/Km respectively

4. CONCLUSIONS

In this paper targets the impact of transmission power and attenuation in free space optical communication system. From result it observed that Q value regarding to transmission power and attenuation lies in the range of 26 to 15 dB and 25 to 14dB and BER lies in the range of 10^{-96} to 10^{-4} and 10^{-90} to 10^{-4} in the transmission power (8dBm) and attenuation (23 dB/km) at distance of 800 meter to 2 kilometer in free space optical communication. There is a significant improvement in BER at 8 dBm in free space optics. But in higher transmission power is not permissive because it affects the human eye and skin. It has been concluded that BER of received data increases when transmission power is decreases and also increase when attenuation increases.

5. ACKNOWLEDGEMENT

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