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Impact of various parameters on the performance of free space optics communication system

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ABSTRACT

The free space optics communication (FSO) systems provide a high bandwidth, small size, light weight, low power and low cost alternative to present microwave systems. In this paper, we have designed a model of FSO system using R Soft simulator to establish an FSO link by a range of 10 km with BER $\sim 10^{-6}$ achieved and reported analysis of various parameter like bit rate, wavelength, transmission power and transmission length.

1. Introduction

Free space optics (FSO) communication system have some distinct advantages over conventional microwave and optical fiber communication systems by virtue of their high carrier frequencies that permit large capacity, enhanced security, high data rate and so on [1,2]. 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 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. 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) [3]. A key issue in FSO system deployment is link availability. Link availability comprises many factors including equipment reliability and network design, but these are well known and fairly quantifiable. The biggest unknown is the statistics of atmospheric attenuation. These statistical data should be obtained either by measurements or from theoretical calculations using atmospheric optics theory. There are various atmospheric attenuation and scatter phenomena that vary widely from one Micrometeorological area to another included scintillation, scattering, beam spread, and beam wander [4]. This focused the impact of transmission power and attenuation in free space optical communication system. It has been shown in [5] that BER of received data increases when transmission power decreases. While it increases with increase in attenuation. Here investigated the impact of with and without Forward error correction in free space optics communication for different bitrates. It had shown that forward error correction technique yields the highest Q^2 value and lowest BER in free space optics (FSO) communication [6]. Performance evaluation of free space optical communication link with different parameters has been observed in this [7]. Author have achieved BER 10^{-7} at 1600 m with bite rate of 2.50 Gbps and BER 10^{-12} at 2000 m with divergence angle 2 mrad in free space optical communication link. In our work, we have presented the simulative investigation of FSO transmission system at different parameter like bit rate, wavelength and transmission power with highest distance 10 km, which is not reported in previous investigated work.

The rest of the paper is organized as follows design of free space optics communication is described in Section 2. The results are presented in Section 3. Finally, conclusion is discussed in Section 4.

2. Design of free space optics

In this design we considered a typical FSO link consisting of a transmitter, FSO channel and receiver. Fig. 1 shows a design of FSO

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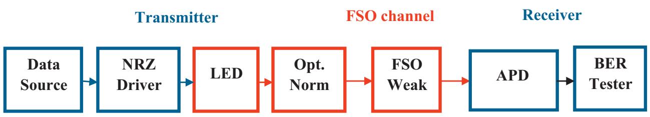

Fig. 1. Design of FSO link.

Fig. 2. FSO compound component and its internal structure.

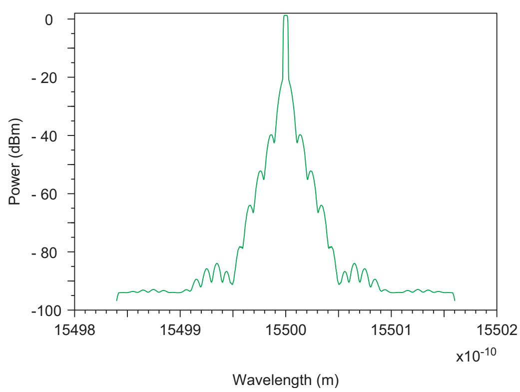

Fig. 3. Power spectrum.

link under study [8–10]. The transmitter consists of a PRBS generator at bit rate 2.50 Gbps, an NRZ Driver, and a directly modulated LED at 1550 nm. Optical power out of the transmitter is 3 dBm. The FSO link has a 10,000 m range with a beam divergence angle of 0.25 mrad. The receiver is a PIN and is followed by a BER Tester.

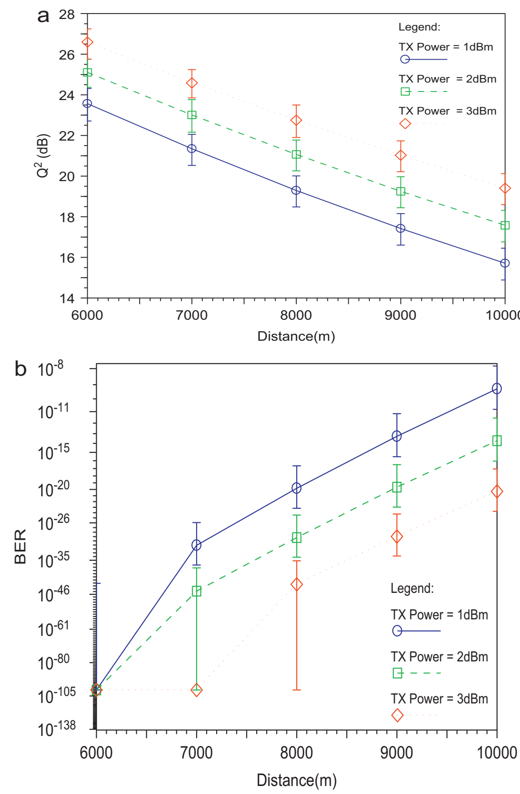

Fig. 5. Q^2 value and (b) BER value with different Tx power.

The FSO compound component is shown in Fig. 2. It consists of Optical Attenuator Block to model geometrical, additional attenuation and optical noise adder block to add the background radiation to received signal.

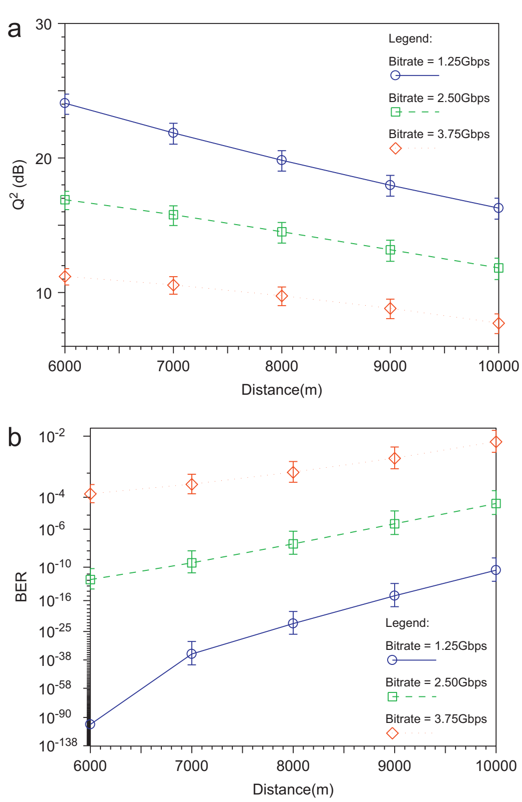

Fig. 4. (a) Q^2 value and (b) BER value with different bitrates.

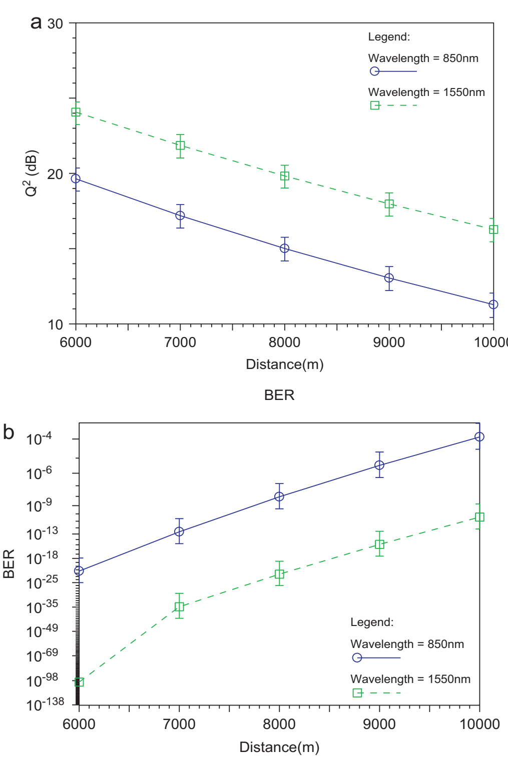

Fig. 6. Q^2 value and (b) BER value with different wavelength.

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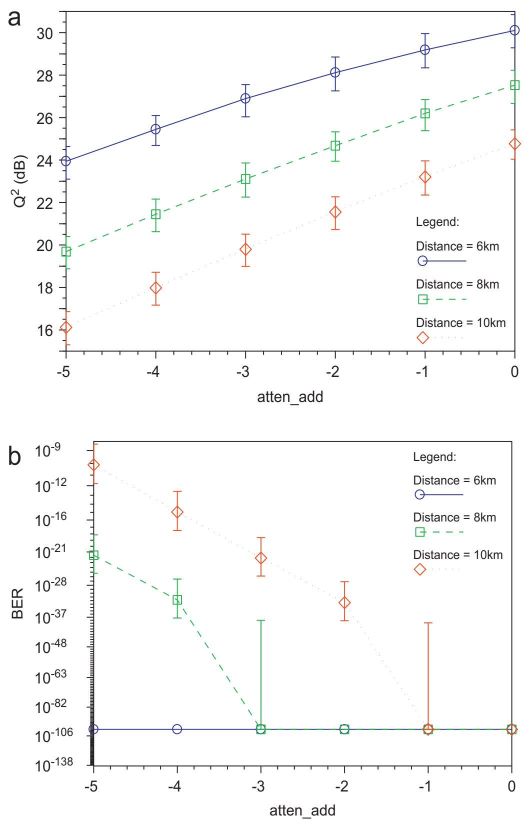

Fig. 7. Q^2 value and (b) BER value with different distance.

3. Results and discussion

In this paper, FSO system is designed with the help of R Soft simulator consisting transmission length 10 km, transmitter aperture diameter 10 cm, receiver aperture diameter 15 cm, beam divergence 0.25 mrad, wavelength 1550 nm, power 3 dBm, line width 2 MHz.

Fig. 3 shows the power spectrum of FSO system at wavelength 1550 nm.

Fig. 4(a) and (b) indicates the graph between Q^2 value and BER versus the transmission distance at different bit rates. From results it has been observed that there is significant decrease in the value of Q factor, which lies within {24, 17 & 11} and {16, 13 & 7} for transmission distance of 10,000 m in case of bit rate 1.25, 2.50 and 3.75 Gbps respectively. Further, it has been observed that there is significant increase in the value of BER, which lies within $\{10^{-2}, 10^{-6}$ & $10^{-11}\}$ and $\{10^{-4}, 10^{-12}$ & $10^{-91}\}$ for transmission distance of 10,000 m in case of bit rate 1.25, 2.50 and 3.75 Gbps respectively.

Fig. 5(a) and (b) indicates the graph between Q^2 value and BER versus the transmission distance at different transmission power. From results it has been observed that there is significant decrease in the value of Q factor, which lies within {27, 25 & 23} and {21, 18 & 16} for transmission distance of 10,000 m in case of transmission power 1, 2 and 3 dBm respectively. Further, it has been observed that there is significant increase in the value of BER, which lies within $\{10^{-9}, 10^{-15}$ & $10^{-26}\}$ and $\{10^{-105}, 10^{-104}$ & $10^{-103}\}$ for transmission distance of 10,000 m in case of transmission power 1, 2 and 3 dBm respectively.

Fig. 6 indicates the graph between Q^2 value and BER versus the transmission distance at different wavelengths. From results it has been observed that there is significant decrease in the value of Q factor, which lies within {24 & 20} and {18 & 10} for transmission distance of 10,000 m in case of wavelength 850 and 1550 nm respectively. Further, it has been observed that there is significant increase in the value of BER, which lies within $\{10^{-4}$ & $10^{-13}\}$ and $\{10^{-20}$ & $10^{-98}\}$ for transmission distance of 10,000 m in case of wavelength 850 and 1550 nm respectively.

Fig. 7(a) and (b) indicates the graph between Q^2 value and BER versus the attenuation addition (atten_add) at different transmission length. From results it has been observed that there is significant decrease in the value of Q factor, which lies within {30, 27 & 24} and {24, 19 & 16} for attenuation addition of −5 to 0 dB in case of 6, 8 and 10 km respectively. Further, it has been observed that there is significant increase in the value of BER, which lies within $\{10^{-10}, 10^{-21}$ & $10^{-106}\}$ and $\{10^{-106}, 10^{-106}$ & $10^{-106}\}$ for attenuation addition (atten_add) of -5 to 0 dB in case of 6, 8 and 10 km respectively.

4. Conclusion

In this work, we have designed a FSO system to establish a FSO link of 10 km length between transmitter and receiver at data rate of 2.50 Gbps. It is concluded from our simulated FSO system using R Soft simulator to establish a FSO link by a range of 10 km with BER $\sim 10^{-6}$ can be achieved with transmitted power by 3 dBm. Above results reported analysis of various parameter that play important role in free space optics (FSO) communication system.

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