# Performance Analysis of Multiple TX/RX Free Space Optical System under Atmospheric Disturbances

Reeba Roy
P G Scholar, Optoelectronics and Communication Systems,
Dept. of ECE
T .K. M. Institute of Technology
Kollam, India

Jaini Sara Babu
Assistant Professor
Dept. of ECE
T. K .M .Institute of Technology
Kollam, India

***Abstract*— Free Space Optical (FSO) communication systems have developed in response to a growing need for high speed and tap proof communication systems. FSO is a communication process that uses light containing information to travel in free space to exchange data between two or more points. Use of Multiple TX/RX in the FSO system increases the performance of FSO system under different atmospheric disturbances. This paper analyzed the performance of Multiple TX/RX FSO system under clear, haze and fog conditions using Q factor, Bit Error Rate (BER) etc. The Free Space Optical link was modelled and simulated using a commercial optical system simulator named OptiSystem 12.0 by Optiwave.**

***Keywords: Free Space Optics (FSO), Spatial Diversity, Q Factor, Bit Error Rate.***

## I. INTRODUCTION

Optical Communication is a communication technique that uses light for the transmission of data. FSO (Free Space Optics) is a version of optical communication with free space as channel. High capacity, low power consumption, light weight, small sizes, high data rates and low costs for satellite cross links are other promises of FSO technology. It is a significant building block for wide area space networks, supporting mobile users, high speed data services for small satellite terminals and serving as a backbone network for high speed trunking. FSO technology is implemented using a laser device which can be mounted on rooftops, corners of buildings or even inside offices. FSO devices look like security video cameras and basically consist of an optical transceiver with a laser transmitter and receiver to provide full duplex capability. FSO technology is useful in cases where fiber optic cables are difficult due to high costs [3]. It is very much efficient in indoor or obstacle less place where line of sight communication can be possible. But in outdoor communication there are environmental effects like fog, haze, rain and dust which limit the performance of FSO link. So, it is important to take several FSO system parameters into consideration such as internal and external parameters. Most significant external parameters are rain, dust, snow, fog, or smog that deteriorate the transmission path and shut down the network [6].

## II. FSO SYSTEM WITH SPATIAL DIVERSITY

Diversity is one of the methods to provide high quality services by sending several copies of the same signal. It gives reliability to the transmission. Spatial diversity is one of the possibilities of including diversity based on the availability of multiple antennas at the transmitter or the receiver. It is possible to linearly increase the throughput of the channel with every pair of antennas added to the system. The use of multiple antennas allows to exploit the spatial dimension of the wireless channel and to provide reliability by simultaneously transmitting the same signal through the new degrees of freedom provided by this spatial dimension. Space diversity is called transmit diversity if multiple transmit antennas are used for transmission purpose and receive diversity if multiple receive antennas are used for receiving purpose [2].

In Free space Optical (FSO) communication, there is a chance for the reduction in the quality of received signal due to the atmospheric disturbances. By using some diversity techniques, it is possible to reduce the fading [5]. Spatial diversity is a technique in which multiple beams are used for the transmission of signals from sender to the receiver. The transmitter section and receiver sections of this system contains multiple lenses which provide the diversity. Multiple beams from the transmitters are send to different paths using lenses. Beams after propagation through the channels get attenuated due to the atmospheric disturbances. The attenuation faced by each path will be different and all the multiple copies of the transmitted signals are then received at the receiver section using lenses.

## III. SYSTEM DESIGN

The fundamental elements that form a FSO system are the FSO transmitter, a FSO channel and the FSO receiver [4]. It is shown in Figure 1. Transmitter includes the PRBS (Pseudo Random Bit Sequence) generator, NRZ pulse generator, a laser source and MZM (Mach Zehnder Modulator). In the single TX/RX simulation shown in Figure 2**,** data generated by the PRBS generator at a data rate of 20 Gbps is encoded and is modulated using MZM where laser source acts as the carrier source with wavelength 1550 nm and power 20 dBm. This modulated light is amplified before transmission to a range of 40 km. The gain of the amplifier is set to 20 dB. Amplified signal is then directly send to the receiver through free space optical channel. Actually free space optical channel is a subsystem of two telescopes with FSO channel between them. The apertures of transmitter and receiver telescopes are set to 5 cm and 20 cm. The beam divergence is 2 mrad.

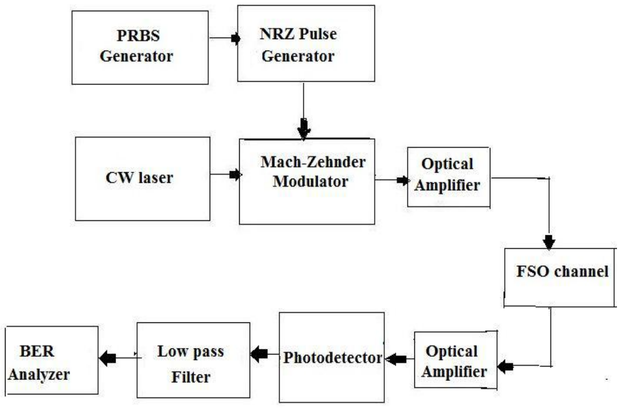


Figure 1 Block diagram of simple FSO system.

In practical cases there is attenuation in the received signal due to atmospheric conditions of the channel. It is possible to set the attenuation losses in the FSO. Typical attenuation values of three conditions clear, haze and fog are 0.43 dB/km, 4.3 dB/km and 43 dB/km respectively [7]. Initially, the attenuation value is set as 0.43 dB/km (clear). The optical signals from the FSO channel is received by photodetector APD. A low pass Bessel filter is used to filter the signal from noise [1]. This simulations uses three visualizers namely optical power meter, optical spectrum analyser and BER analyser. Optical spectrum analyzers provide the facility to analyse the optical spectrum. Optical power meters gives the power received in both dBm and Watts. BER analyzer automatically calculate the BER value, Q factor and display eye diagram.

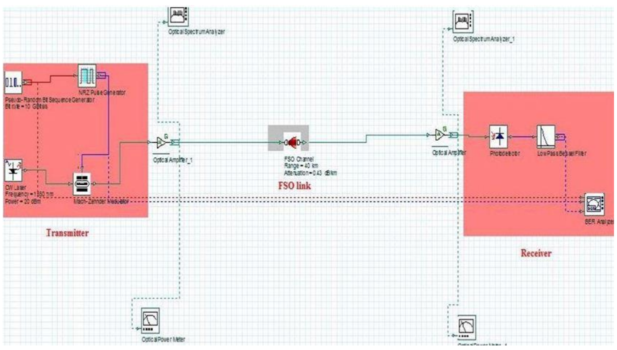


Figure 2 Simulation layout of single TX/RX FSO system

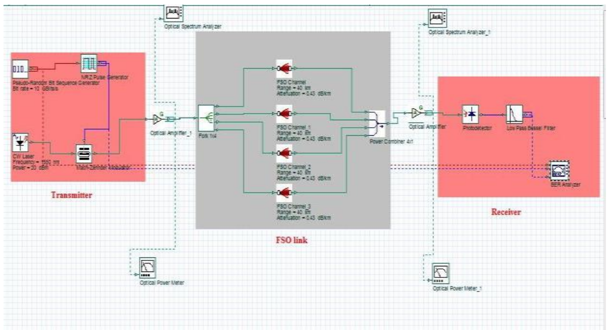


Figure 3 Simulation layout of multiple TX/RX FSO system.

In the simulation layout shown in Figure 3, instead of one FSO channel, four channels are used. Fork is used for duplicating the input beam to all the channels. Output port of fork is set as 4, since four channels are considered. At the receiver end, the optical signals from these channels are combined with the help of a power combiner having 4 input ports.

## IV. RESULTS AND DISCUSSIONS

Simulations of both 1 TX/1 RX and 4 TX/4 RX FSO systems with a power of 10 dBm, range of 1 km and bit rate of 10 Gbps are analysed under three conditions clear, haze and fog. Figure 4 represents the FSO system under clear condition. 4 TX/4 RX show a better performance with high Q factor and low BER.

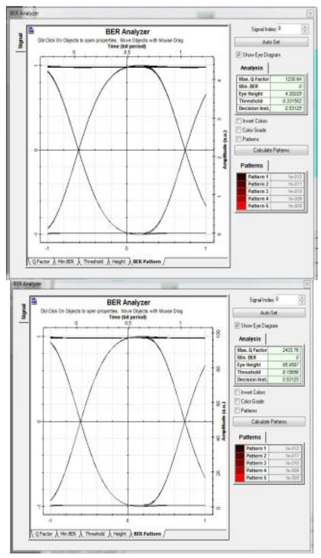

Figure 4 Eye diagram of (a) single TX/RX and (b) multiple TX/RX FSO system under clear condition.

Eye diagrams of both FSO systems under haze condition are shown in Figure 5. It is seen that in this case also the 4 TX/4 RX FSO system performed better. But its Q factor is less than that of 4 TX/4 RX under clear condition. Because attenuation due to haze is higher than that of clear conditions.

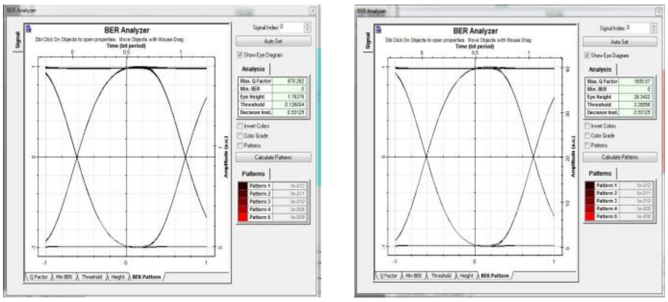

Figure 5 Eye diagram of (a) single TX/RX and (b) multiple TX/RX FSO system under haze condition.

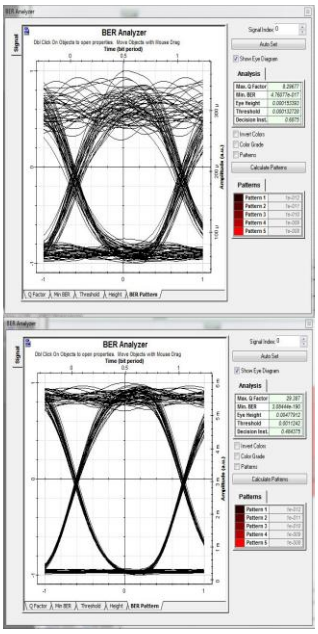

Figure 6 Eye diagram of (a) single TX/RX and (b) multiple TX/RX FSO system under fog condition.

The most important challenge faced by FSO system is fog. Its attenuation is taken as 43 dB/km. In FSO system under fog with same other conditions, it is seen that Q factor of 1 TX/1 RX FSO system is only 8.29 while that of 4 TX/4 RX is 29.37. It is shown in Figure 6. This higher Q factor obtained is due to spatial diversity. Figure 7 shows graphical comparison between 1 TX/1 RX and 4 TX/4 RX under the clear, haze and fog conditions.

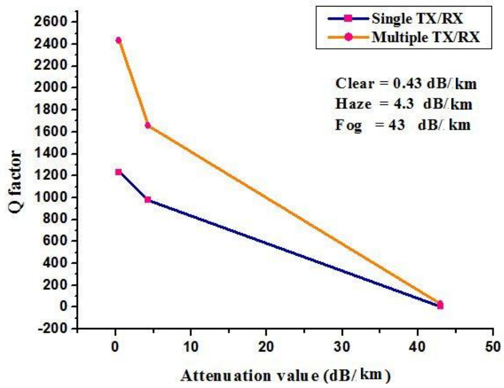


Figure 7 Graphical representation of multiple TX/RX FSO system over single TX/RX FSO system.

## V. CONCLUSION

Free Space Optics is a promising communication technology in the near future. Due to the atmospheric disturbances, there is distortion of signals at the receiver. But by using new techniques it is possible to reduce the atmospheric effects on the optical signal. Incorporation of spatial diversity in the FSO system increased the efficiency of systems under different disturbances. Eventhough Q factor of FSO system decreases on increasing attenuation, the 4 TX/4 RX shows a higher Q factor so better performances.

## REFERENCES

[1] Bikram Beri, Neel Kamal, "WDM based FSO link optimizing for 180km using Bessel Filter", International Journal of Research in Engineering and Technology,Volume: 03, Issue: 03 March 2014.

[2] Pravin W. Raut, Dr. S.L. Badjate, "Diversity Techniques for Wireless Communication", International Journal of Advanced Research in Engineering and Technology, Volume 4, 2013.

[3] Sameer Asif, Prashant KR. Yadav, "An Overview to Free Space Optics and its advantages over Fiber Optics", International Journal of Electronics and Communication Engineering, Vol. 1, Aug. 2012.

[4] Nur Haedzerin M .D. Noor, Ahmed Wathik Naji and Wajdi Al Khateeb, "Performance analysis of a free space optics link with multiple transmitters/receivers", IIUM Engineering Journal, Vol. 13, No. 1, 2012.

[5] Sharma.V, Kaur G, "Degradation measures in Free Space Optical communication (FSO) and its mitigation techniques - a review", International Journal of Computer Applications, 2012.

[6] Scott Bloom, Eric Korevaar, John Schuster, Heinz Willebrand, "Understanding the performance of free-space optics", Journal of optical networking, Vol. 2, No. 6, June 2003.

[7] I. I. Kim, B. McArthur, and E. Korevaar, "Comparison of laser beam propagation at 785 nm and 1550 nm in fog and haze for optical wireless communication", Optical Access Incorporated, San Diego CA, 2001.