Performance Evaluation of Multiple Transceiver FSO for different Weather Conditions

Priyanka sharma[1] and Mrs. Himali sarangal[2]

[1]*Student at G.N.D.U*
[2]*Assistant professor at G.N.D.U*
[1]*s.priyanka1191@gmail.com,* [2]*himali.sarangal@gmail.com*

Abstract

Free Space Optical Communication has been developed to cover the longer distances with the growing needs of high speed. It is a data transmission technology from one point to another point by using laser beam carrying information in free space. Multiple transmitters/receivers (TX/RX) are used to improve the performance and quality of Free Space Optics (FSO) communication system under different weather conditions. This paper analyzes the performance of multiple transceivers system by the received power level (PR), Q factor and bit error rate (BER) under clear, fog and haze conditions. From the measured data is possible to calculate visibility which is the main factor for quality and *estimation* for *the availability and reliability of FSO link. The Free Space Optical link was modelled and simulated using a commercial optical system simulator named OptiSystem by Optiwave.*

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

1. Introduction

Free space optical (FSO) (*i.e.*, optical wireless) communication provides an attractive approach to RF-based wireless communication and is a line of sight technology. Distance between transmitting and receiving points can be from several meters up to a few kilometers. It is a growing up technology which offers full duplex and usually protocol independent data transmission between two stations. line of site communication can be possible without the turbulence environment and it is very much efficient in indoor or obstacle less place but in outdoor communication there is environmental effect like fog, haze, rain and dust that limits the FSO link[1]. Signal diverts from its actual path by the scattering caused by different earth unequal points The combination of environmental attenuation and earth inequalities losses provides total attenuation. For better communication we also need large link distance, less scattering, less absorption, less misaiming, large laser power & data bits. We also have to make a reduced cost, faster implementation and easy installable over long distances[2]. To get these and to reduce the effect of these environmental conditions we need a special quality of FSO link.

2. Spatial diversity in FSO

High quality services can be obtained by sending several copies of same signal with the help of diversity. Spatial diversity is a type of diversity based on having multiple antennas at the transmitter and the receiver[3]. Throughput of the channel can be increased linearly with every pair of antenna added to the system. The use of multiple antennas in spatial increases the reliability and availability by simultaneously transmitting the same signal. Spatial diversity is known as transmit diversity if multiple antennas are used for transmission purpose and receive diversity when multiple antennas are used for receiving purposes[4]. In FSO communication system, quality of the signal decreases due to

environmental effect like fog, haze, rain and dust. In spatial diversity,it is possible to reduce fading and in response quality of signal can be increased. To provide diversity in a system multiple lenses are used in the transmitter and receiver section. Multiple beams from the transmitter are send to different paths using lenses,beams after propagation through the channel get attenuated due to atmospheric disturbances. The attenuation faced by each path will be different and the multiple copies of transmitted signal are then received at the receiver section using lenses[5].

3. System Design

The fundamental elements that form the FSO system are the FSO transmitter , channel and receiver. Analysis of performance of Multiple Transreciever system in FSO link is done by using the OptiSystem Version 7.0. The power of the TX is set to be 10dbm and the frequency is 353 THz or 850 nm. The output of the each TX is connected to the respective fork which is used to replicate the number of output ports so that signals coming out from their respective fork's output has the same value with the output signal from the former component connected to it. From a single source multiple laser beams are produced by the first fork connected to the TX[6]. Then, the output signals will be connected to another set of forks respectively to produce another set of multiple laser beams. Then before sending to the FSO channel these multiple laser beams are combined together with a power combiner. The output coming out from the power combiners are then sent to the FSO channel. This system is a subsystem of two telescopes with the intermediate FSO channel. The apertures of the Transmitter and Receiver are set to 2.5 cm and 8 cm respectively. The distance of the channel is set to 2 km and the beam divergence is 2 mrad. The work will involve the modification of the single Transmitter and Receiver layout design to enable the simulation of the multiple Transceivers.

Table 1. Parameters Chosen

PARAMETER	SYM-BOL	VALUE
Transmission data rate	Bit rate	1.25 gbps
Link distance	Z	2 km
Transmitted power	Pt	10 dbm
Wavelength	F	850nm
Transmitter aperture	Dt	2.5cm
Receiver aperture	Dr	8cm
Extinction ratio	Re	10 db
Beam divergence	theta	2 mrad
Equipment loss	Leqip	3.6 db
Line width	W	10 Mhz

In practical cases there is attenuation in the received signal due to weather conditions of the channel. We should set the attenuation losses in the FSO. Typical attenuation values of three conditions clear, fog and haze are 0.43dB/km, 43dB/km and 4.3 dB/km respectively [7]. At first the attenuation value is set as 0.43dB/km (clear). The optical signal is received by optical receiver in the FSO channel. These simulations include three visualizer's namely optical power meter, BER analyser and optical spectrum analyser. Optical spectrum analyzers analyse the optical spectrum. Optical power meters can measure the power received in both dBm and Watts. BER analyzer can calculate the BER value, display eye diagram and Q factor.
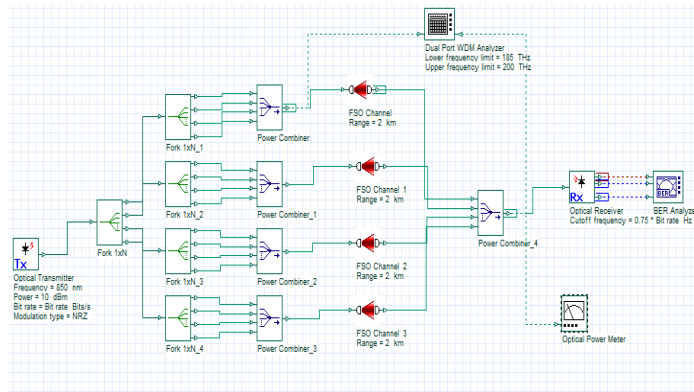
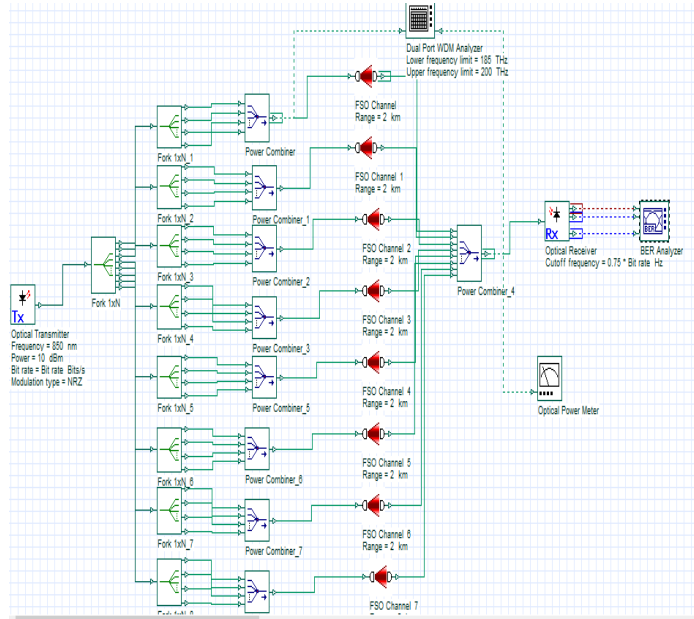**Figure 1. Simulation Layout of 4Tx/4Rx FSO System**

Figure 2. Simulation Layout of 8Tx/8Rx FSO System

4. Results and Discussions

Simulations of both 1 TX/1 RX ,4 TX/4 RX amd 8 TX/8 RX FSO systems with a power of 10 dBm, range of 2 km and bit rate of 1.25 Gbps are analysed under three conditions clear, haze and fog. Figure 3 represents the FSO system under clear condition. 4 TX/4 RX show a better performance with high Q factor and low BER.
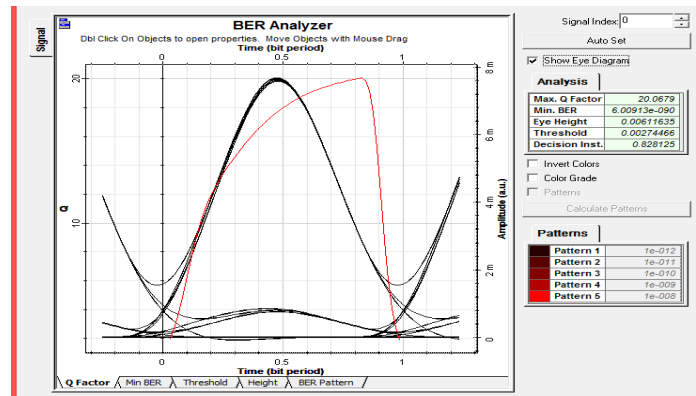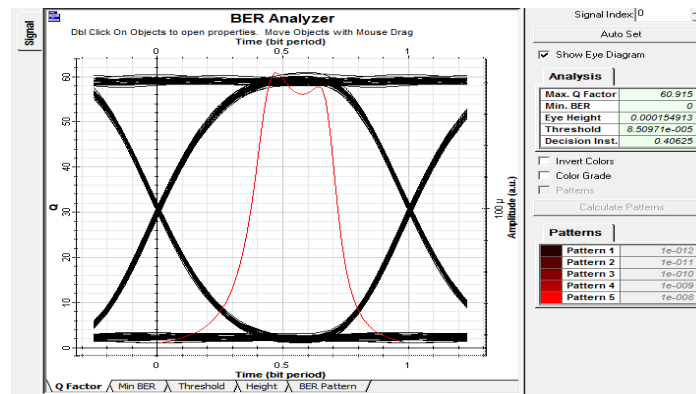
Figure 3.1. Eye Diagram of Single Tx/Rx during Normal Conditions

Figure 3.2. Eye Diagram of 4 Tx/4 Rx during Normal Conditions
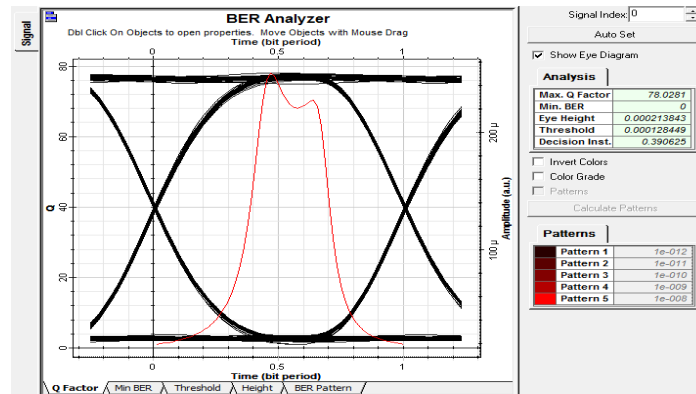
Figure 3.3. Eye Diagram of 8 Tx/8 Rx during Normal Conditions

Eye diagrams of both FSO systems under haze condition are shown in Figure 4. It is seen that in this case also the 4 TX/4 RX , 8 TX/8 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.
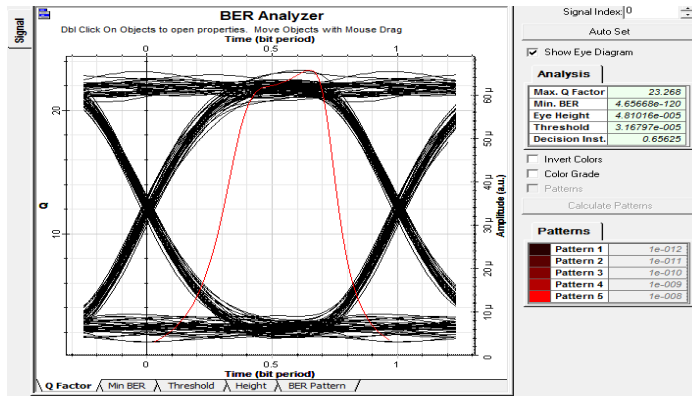
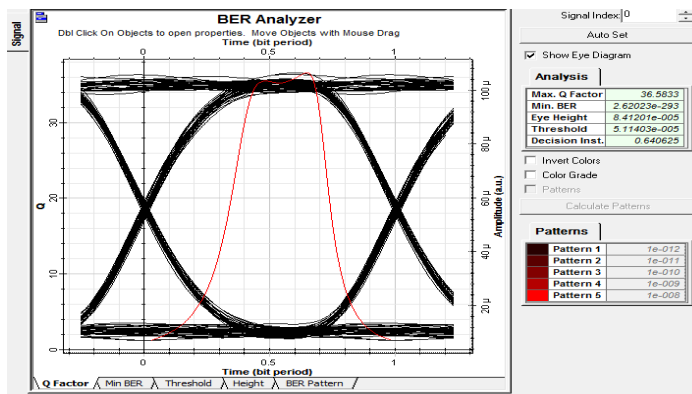**Figure 4.1. Eye Diagram of Single Tx/Rx during Haze**

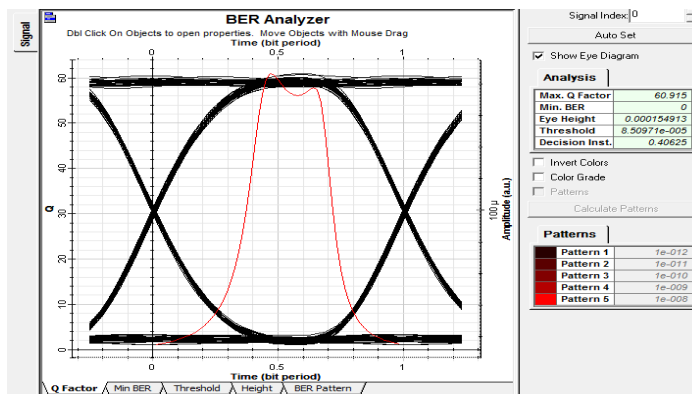**Figure 4.2. Eye Diagram of 4 Tx/4 Rx during Haze**

Figure 4.3. Eye Diagram of 8 Tx/8 Rx during Haze

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 7.11, 4 TX/4 RX is 19.7 while that of 8 TX/8 RX is 36. It is shown in Figure 5. This higher Q factor obtained is due to spatial diversity.
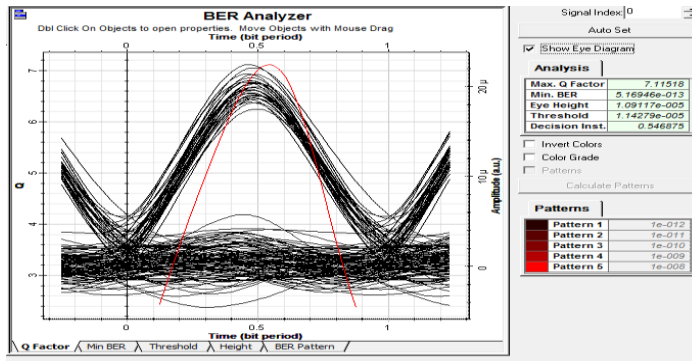
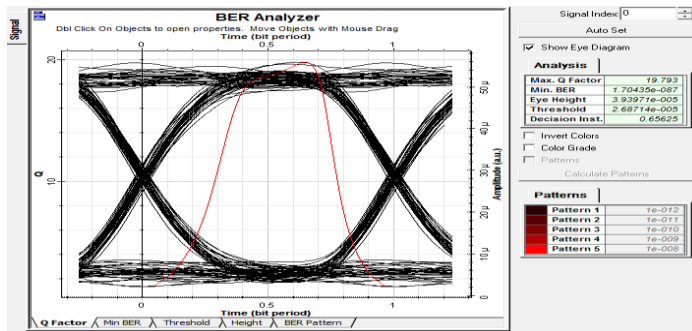**Figure 5.1. Simulation Layout of Single Tx/Rx during Fog**

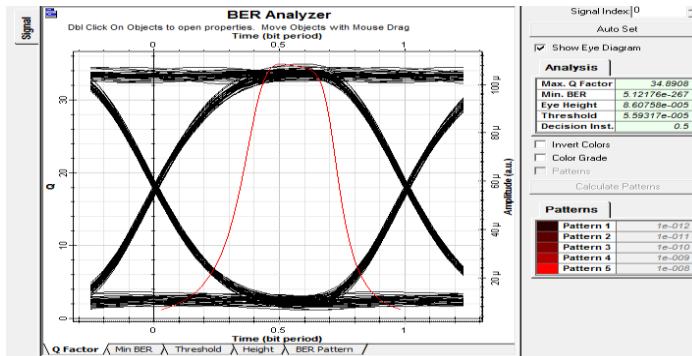**Figure 5.2. Simulation Layout of 4 Tx/4 Rx during Fog**

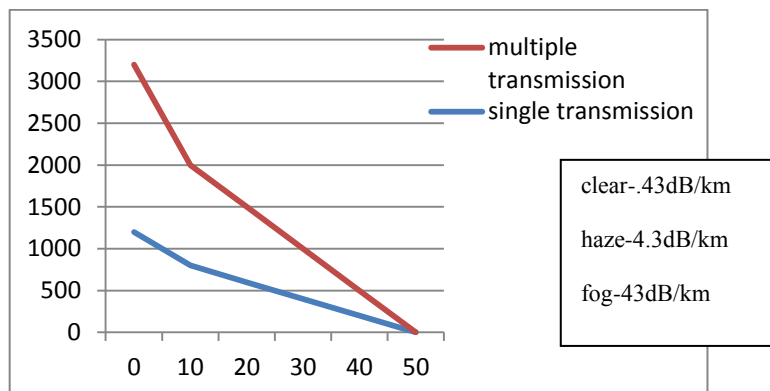**Figure 5.3. Simulation Layout of 8 Tx/8 Rx during Fog**

Figure 6. Shows Graphical Comparison between 1 **TX/**1 **RX and Multiple TX/RX under the Clear, Haze and Fog Conditions. Y axis Represents the Quality Factor and X Axis Represents the Attenuation in db/km**
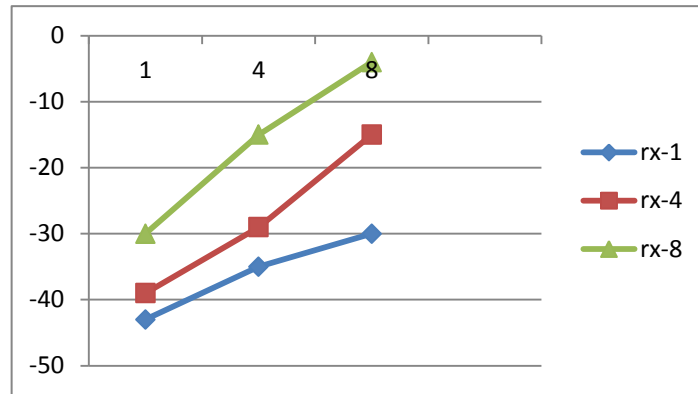
Figure 7. Shows Graphical Comparison between Received Power and Number of Receivers . Y axis Denotes Received Power Level in dBm and X axis shows Number of Receiver

5. Conclusion

In the near future Free Space Optics is a promising communication technology. There is distortion of signals at the receiver due to the atmospheric disturbances. By using new techniques it is possible to reduce the distortion in the atmospheric effects on the optical signal. efficiency is increased by the Incorporation of spatial diversity in the FSO system under different disturbances. Even though Q factor of FSO system decreases on increasing attenuation, the 8 TX/4 RX shows a higher Q factor and better performances.

Acknowledgments

References

[1]   S. Bloom, E. Korevaar, J. Schuster and H. Willebrand, "Understanding the performance of free-space optics", Journal of optical networking, vol. 2, no. 6, **(2003)** June.

[2]   N. Haedzerin, M .D. Noor, A. W. Naji and W. Al Khateeb, "Performance analysis of a free space optics link with multiple transmitters/receivers", IIUM Engineering Journal, vol. 13, no. 1, **(2012)**.

[3]   P. W. Raut, Dr. S. L. Badjate, "Diversity Techniques for Wireless Communication", International Journal of Advanced Research in Engineering and Technology, vol. 4, **(2013)**.

[4]   S. Asif, Prashant K R. Yadav, "An Overview to Free Space Optics and its advantages over Fiber Optics", International Journal of Electronics and Communication Engineering, vol. 1, **(2012)** August.

[5]   A. Nabih Zaki Rashed Mohamed, and E. M. Amina, "El-Nabawy; The Effects of the Bad Weather on the Transmission and Performance Efficiency of Optical Wireless Communication Systems in: I.J. Image", Graphics and Signal Processing, 10.5815/ijigsp, vol. 7, no. 8, **(2012)**, pp. 68-83.

[6]   B. McArthur Kim 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)**.

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

[8]   R. Kvicala, V. Kvicera, M. Grabner and O. Fiser, "BER and avalibility measured on FSO link", Radioengineering, vol. 16, **(2007)**, pp. 7-12.

[9]   X. Zhiu and J. M. Fellow, "Free space optical communication through atmospheric turbulence channels" IEEE transactions on communications, vol. 50, no. 8, **(2002)** August.

[10] N. A. Mohammad, A. S. El Wakeel and M. H. Aly, "Pointing error in FSO link under different weather conditions", International journal of Video & Image processing and network security IJVIPNS-IJENS, vol. 12, no. 01.

Authors

Priyanka sharma, student at Guru Nanak Dev University.

Mrs. Himali sarangal, assistant professor at Guru Nanak Dev University.