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10 Gbps Free Space Optics Link under the Impact of Atmospheric Turbulences

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Abstract: *With the advancement in communication technologies, need of high data rates have been evolved over the years. Our work is focused in designing such a system that can withstand effects of atmospheric turbulences. A single channel 10 Gbps Free Space Optics (FSO) systems is designed to transmit data under the impact of transmitting pointing errors over a distance of 3000 m. Minimum acceptable Bit Error Rate (BER) is obtained and successful transmission of data is replicated by Eye Diagrams.*

Keywords: *Free Space Optics (FSO), Bit Error Rate (BER)*

I. INTRODUCTION

Communication has become an important part in our daily routine. Communication means exchanging or transferring information by speaking, writing from one place to another place using some medium. Different services are used to transmit information like voice, video, text, data etc. Now-a-days there is a huge demand of these services. Light technology has been used to achieve high data rates and for greater bandwidth [1, 2].

Free space optics is essential for worldwide broadband network. It is a growing technology to carry a large amount of information and have capacity to handle a high data rates. Free space optics is a line of sight technology which uses lasers (transmitter) and photo detectors (receiver) to provide full duplex transmission of data, voice and video in certain applications. FSO is a optical communication technology that uses light propagating in free space which transmit the data wirelessly for telecommunication or computer network [3-6].

The principle of FSO is similar to the optical fiber cable but the difference is that the optical beams are sent through free air instead of OFC cores that is glass fiber. In 1870, the Alexander Graham Bell demonstrated his first wireless telephone system named as "Photo Phone". It was the world first wireless telephone system. It converts the sound wave to electrical telephone signals and transmitted voice signal over a distance by using sunlight as a carrier [7, 8]. In 1960, there is an invention of first working laser at Hughes Research Laboratories, Maliber, California.

There is a great advancement was observed and technology of FSO has changed [9]. In 1962, the researchers in the MIT Lincolns Laboratory using GaAs LED source to transmit television signals up to 48Km distance. In 1970s, Nippon Electric Company (NEC, Japan) made the first full duplex FSO link of 14 Km distance between Yokohama and Tamagawa using He-Ne laser of 0.6328 [10]. The first inter-satellite laser communication link was successfully demonstrated by European Space Agency (ESA) between two satellites SPOT-4 and ARTEMIS for optical data-relay services at 50 Mbps [11]. From 1990s to till date the research in this field has increased substantially.

FSO communication is subjected to atmospheric effects. FSO technology uses atmospheric channel as a propagating medium. There are various challenges in FSO like clouds, snow, fog, haze etc which cause attenuation in optical signal and limit the link distance [12].

During dense fog conditions there is a high attenuation which is more than 350db/km [13]. The impact of rain is not more like fog. There is a 2.5mm/hr attenuation loss at light rain and 25mm/hr attenuation loss at heavy rain [14]. The size of snow particles are between rain and fog particles. The attenuation due to snow is more than snow but less than fog. The attenuation is ranging between 30-350db/km [15].

II. SYSTEM DESCRIPTION

The performance of proposed FSO link is evaluated under the impact of atmospheric turbulences in OptiSystem software. Figure 1 shows the schematic diagram of proposed system under the impact of atmospheric turbulences. The turbulences are considered as attenuation of 5dB/Km.

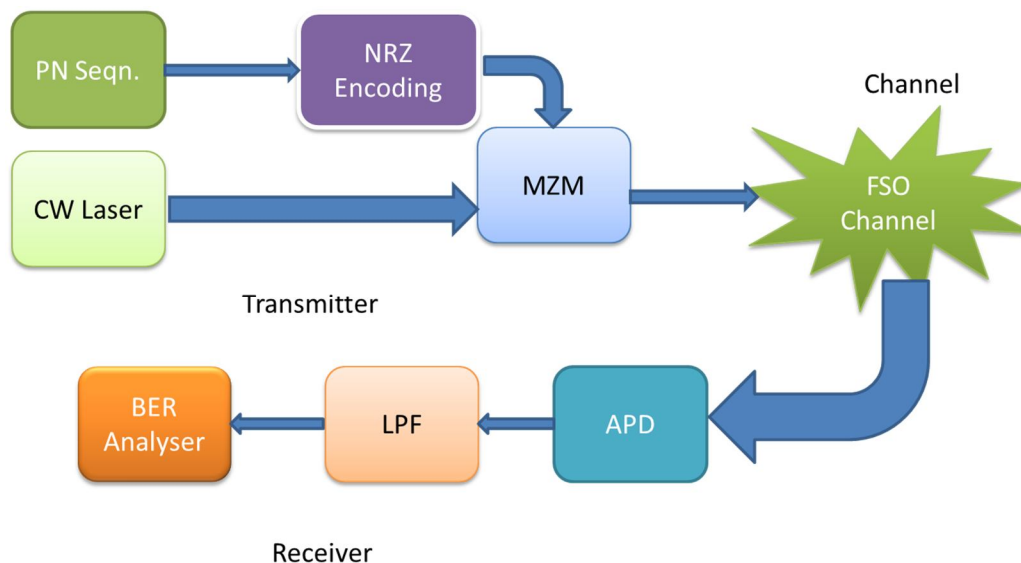


Fig. 1. Proposed FSO system under the impact of Turbulences

III. RESULTS AND DISCUSSION

In this section, results obtained from the simulation of proposed single channel FSO system.. Figure 2 shows the measured minimum BER and max q factor for proposed system up to 18000 mtr while Figure 3 Shows the measured minimum BER and max q factor for proposed system upto 3000 mtr under the impact of attenuation of 5dB/Km.

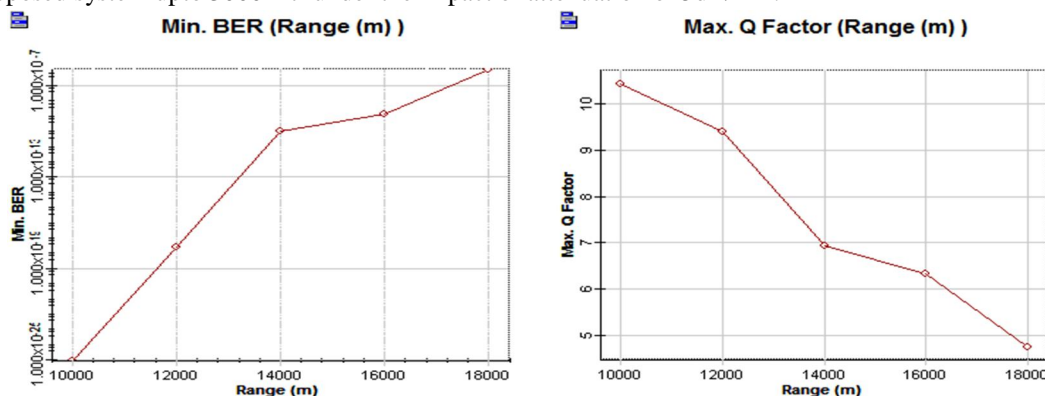


Fig 2. Minimum BER and Max Q Factor vs Range

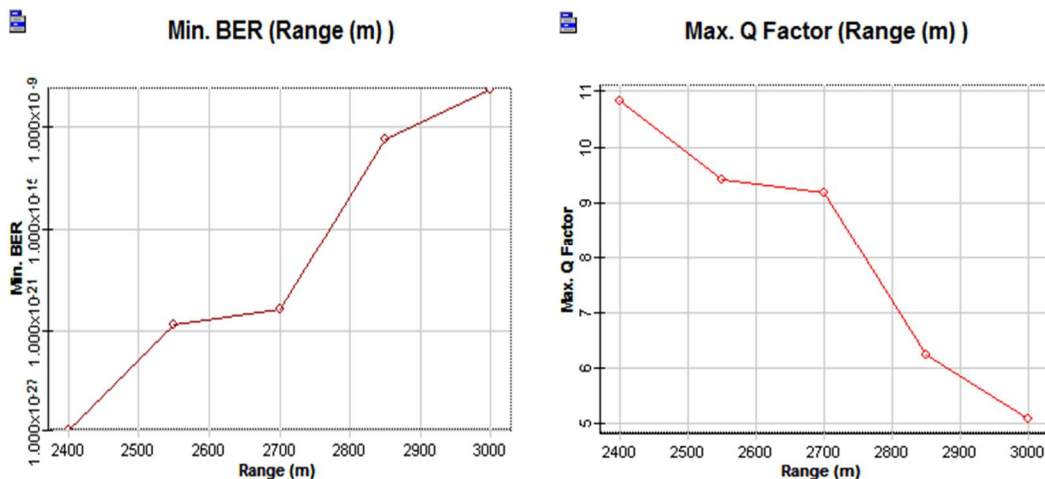


Fig. 3 Minimum BER and Max Q factor Vs Transmitted Pointing errors

The value of BER for system with is noted as 7.94×10^{-26} , 1.06×10^{-10} and 1.15×10^{-6} at a distance of 10000, 14000 and 18000 mtr respectively without any turbulence whereas Max Q factor of 10.43, 6.92 and 4.73 at a distance of 10000, 14000 and 18000 mtr respectively was measured. The system is further subjected to turbulences that is attenuation of 5dB/Km. The value of BER for system with is noted as 1.22×10^{-27} , 1.95×10^{-20} and 1.66×10^{-7} whereas Max Q factor of 10.81, 9.17 and 5.09 at Free Space transmitting 2400, 2700 and 3000 mtr respectively was measured.

Figure 4 and 5 shows the eye diagrams for both the cases with turbulence and without turbulence. As it is clear from the eye opening that data has been successfully received.

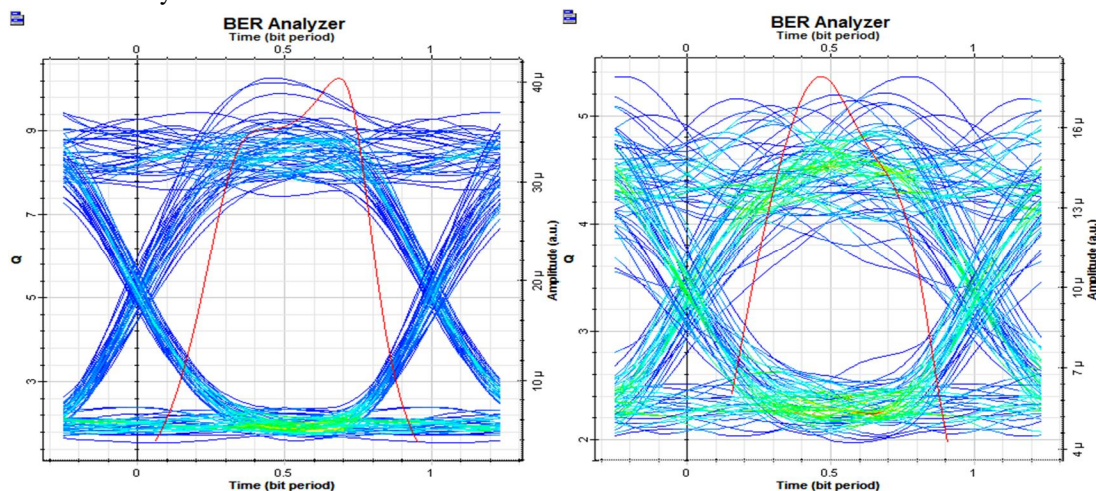


Fig. 4 Eye diagram at 10000 mtr and 18000 mtr without Turbulences

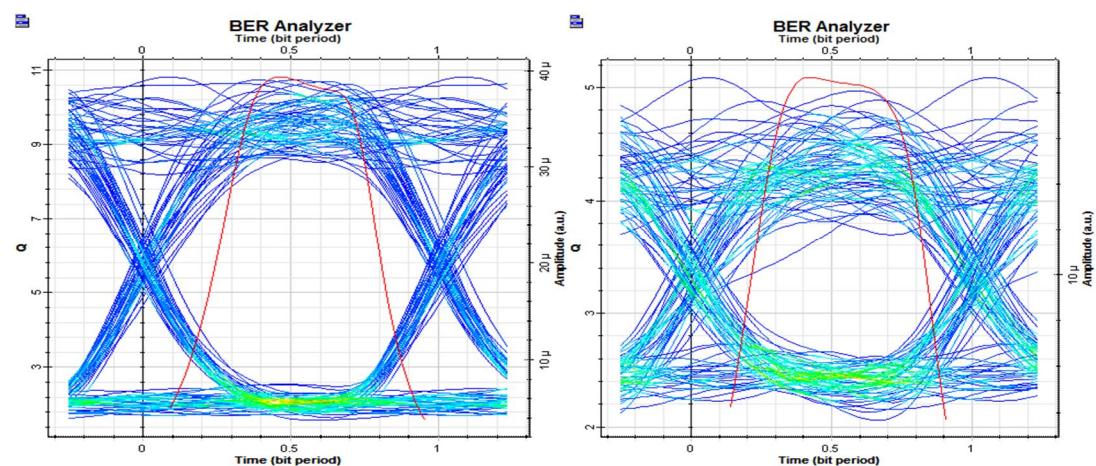


Fig. 5 Eye diagram at 2400 mtr and 3000 mtr and attenuation of 5 dB/Km

IV. CONCLUSION

In this work, we have successfully transmitted 10 Gbps of data over a distance of 18000 mtr without any turbulences and upto 3000 mtr with attenuation of 5dB/Km. The reported result shows the successful transmission of 10 Gbps data Is-OWC link with acceptable BER and Q factor and eye pattern under the impact of transmitting pointing errors.

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