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PERFORMANCE ANALYSIS OF FSO LINK UNDER EXTREME WEATHER CONDITIONS

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***Abstract*— free space optics is currently a well-known technology for its use in the systematic transport of enormous volumes of data. It has proven to be a feasible technique for assisting existing networks with high data transfer safely across a moderate distance without the usage of fiber. Free space optics has emerged as the most viable option to the broadband market's current bottlenecks. However, certain external characteristics have a significant impact on the performance of free space optics. We calculate signal loss owing to environmental elements such as fog, snow, rain, blurring,and scintillation, as well as a detailed approach for reducing their impact on free space optical network performance. Signal quality has improved significantly using the provided methods.**

***Keywords*—Free space optics (FSO), Attenuation, Losses in FSO, EDFA.**

I. INTRODUCTION

Free Space Optics (FSO) is a wireless Line Of Sight (LOS) communication technique that sends data over the air or vacuum by using light. FSO allows fiber optical communication by allowing data to be sent by light propagation in free space. Free Space Optics has similar characteristics to fiber optics, but at a lesser cost and at a much faster rate. It's a technique that transmits data via the atmosphere using visible to near-infrared (NIR) light [1]. The FSO connection is gaining popularity because it overcomes the mileage problem in local networks (LANs). Fiber optic transmission is also known as FSO. The problem is because the Sender applied and sent the laser beam through the aura, rather than the recipient.

II. STRUCTURE DESIGN

Various experiments has been carried out to analyze the Q factor versus attenuations caused by different atmospheric phenomena and for different distance lengths between transmitter and receiver, In the case when the wavelength is 1550 nm, the transmission quality will be good up to 270 m. similarly in worse atmospheric phenomena, quality signal transmission is impossible to achieve at distances greater than 270m. In order for this to be achieved, certain parameters of the system must be changed on the transmitting side, such as increasing the source power or using different amplification techniques. [1, 2]

Table 1 shows the various attenuation values of various external conditions over a specific range

S.no	Title	attenuation
01	Heavy fog	125db/km
02	Moderate fog	42.2db/km
03	Light fog	20db/km
04	Rain	15db/km
05	Dry snow	128db/km
06	Wet snow	110db/km

Table 1.Attenuation of various environmental factors in the FSOsystem

Based on the initial setup, as shown in fig 1, it can be concluded that the FSO system shows the best performance at a wavelength of 1550 nm, where quality transmission is achieved over 240 m distance for 40 dB/km attenuation. After that the quality of the received signal starts degrading and reaches its worst at a range of 270. The current system works on the wavelength of 1500nm, power 10mW, beam divergence of 2mrad, receiver aperture diameter of 7.5cm and the system is exposed to have an attenuation of 40db/km.
The same system gives a range of 50m if it is exposed to attenuation of 454db/km [4]

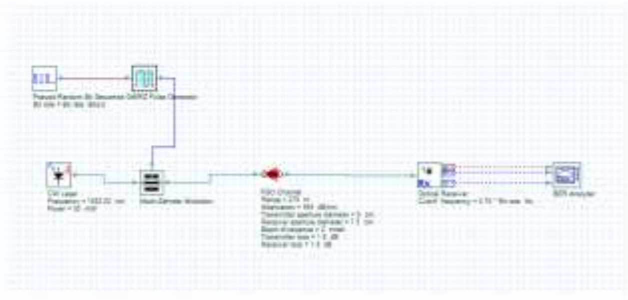


Fig. 1: the initial design with receiver aperture 7.5cm, beam divergence 2mrad

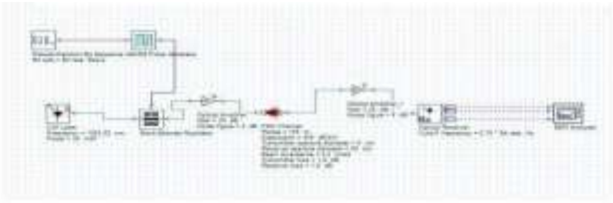


Fig 2. The Simulated structure design with pre-on-post EDFA compensation with receiver aperture 20cm and beam divergence0.2mrad.

A. SYSTEM MODEL

The system model used for the simulation in the software Opti-System is given in Fig. 1. At the input of the observed system are Pseudo-Random Bit Sequence (PRBS) and NRZ (Non-Return to Zero) Pulse Generator that are fed together to the Mach- Zehnder Modulator. The binary sequence of pseudo-random bits generated in the PRBS Generator passes through the NRZ Pulse Generator where that bit sequence is converted into electrical pulses. The pulse thus obtained and the signal from the source modeled by the CW (Continuous-wave) Laser are modulated in a Mach-Zehnder Modulator. The output thus obtained is an optical signal of variable intensity in accordance with the input electrical signal. A modulated optical signal is fed to the input of the componentrepresenting the FSO channel, where attenuation values due to atmospheric influences can be entered. The Optical Receiver with Cutoff Frequency = 0.75 *Bit-Rate Hz is located on the receiving side, and a BER analyzer is connected to it, which is used to read the measured parameters. [1]

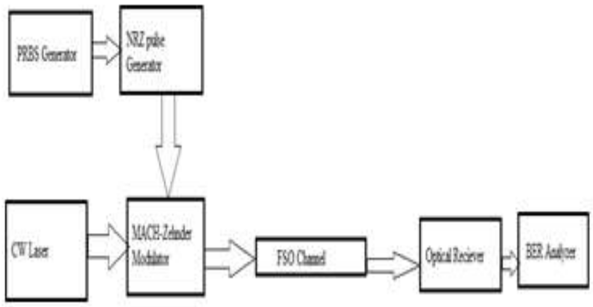


Fig. 3. Block diagram of the system model

The system was simulated with a transmitter power of 30 mw and at wavelength of 1550 nm.

Phase 1

Different values of receiver aperture dimeter were taken to analyze the best and worst performance of FSO network at constant values of beam divergence

Phase 2

Different values of beam divergence were analyzed to draw the best and worst performance of FSO network at constant values of receiver aperture diameter

Phase 3

Amplification techniques using EDFA, RAMAN and SOA amplifier were done for pre, post and pre on post compensations to analyze the q- factor.

III. RESULTS AND DISCUSSION

The attenuation of the optical signal at a distance R, due to fog and haze, is determined by the Beer-Lambert law [4],

$$Attfog = e^{-afogR} \qquad (1)$$

Based on all the theoretical and practical measurements the fog attenuation is implemented graphically and pictorially as eye diagram.

The FSO performance is evaluated under the best and worst conditions, and mutual comparison of FSO performance is drawn and plotted as illustrated in figure 4,
Snow attenuation is classified into dry and wet [7]. Wet snow is partially melted and denser while dry snow is less dense and easily drifted by the wind.

The specific attenuation (in dB/km) is given by

$$Attsnow = b1S^{b2} \qquad (2)$$

FSO performance is evaluated under worst and best range with constant beam divergence and varying receiver aperture diameter and mutual comparison wereplotted as shown in thefigure 5.

Raindrops of large enough size also cause reflection and refraction of optical signals.

The specific attenuation (in dB/km) is obtained as [7]

$$Attrain = k1R^{K2} \qquad (3)$$

FSO performance is evaluated under best and worst cases scenario of beam divergence and receiver aperture diameter and comparison with initial design is plotted as shown in the figure 6.

Minimum transmission range By Kim cruise model [3]

$$Pr = P \frac{AR}{t_{\emptyset} R^2} Att \tag{4}$$

The range can be obtained as [3].

$$Rfog \quad \frac{=2w_0 \frac{\propto_{fog}}{2\emptyset} \sqrt{P_t A_r}}{\propto_{fog}} \tag{5}$$

$$Rrain \quad = \frac{=2w_0 \frac{lnz_1}{2\emptyset} \sqrt{P_t A_r}}{lnz_1} \tag{6}$$

$$Rsnow \quad = \frac{=2w_0 \frac{lnz_2}{2\emptyset} \sqrt{P_t A_r}}{lnz_2} \tag{7}$$

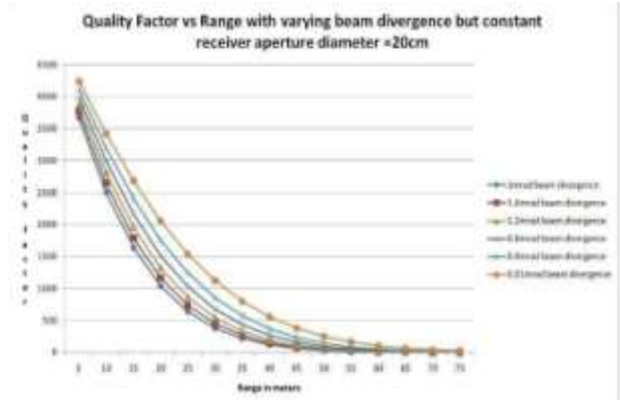
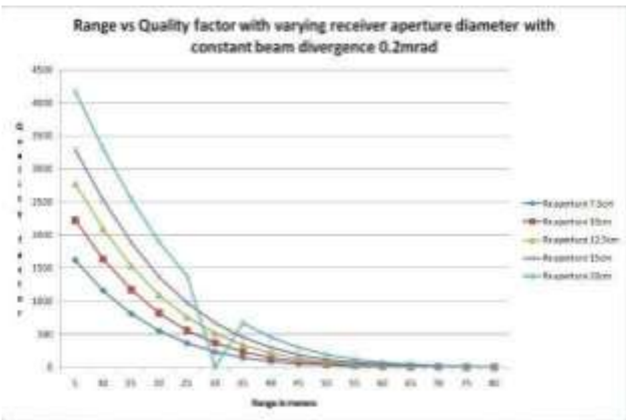
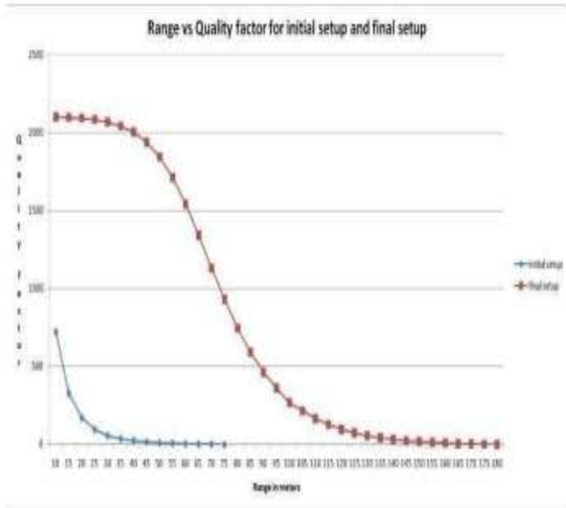


Fig 4: Q factor for different FSO ranges at varying beam divergence





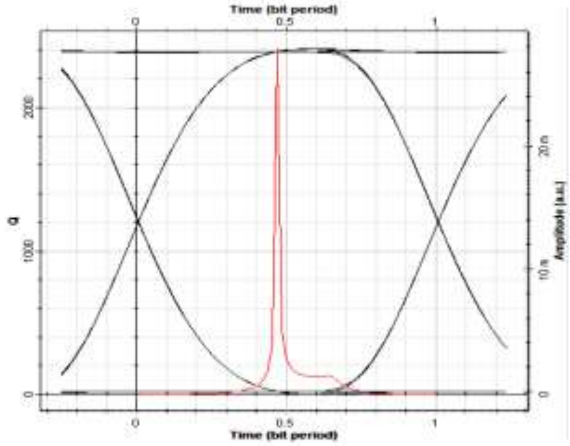


Fig i: Eye diagram at range 5m at beam divergence 0.2

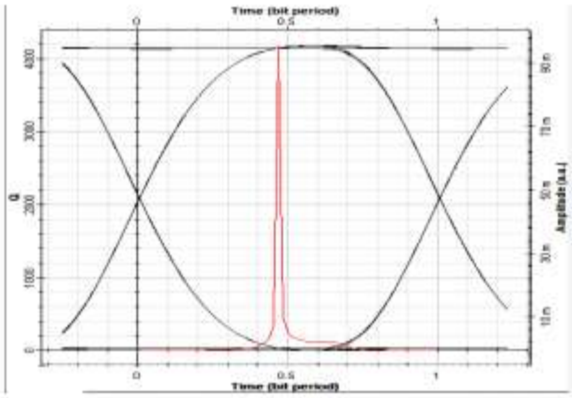


Fig iii: Eye diagram of FSO network at receiver aperture diameter 20cm

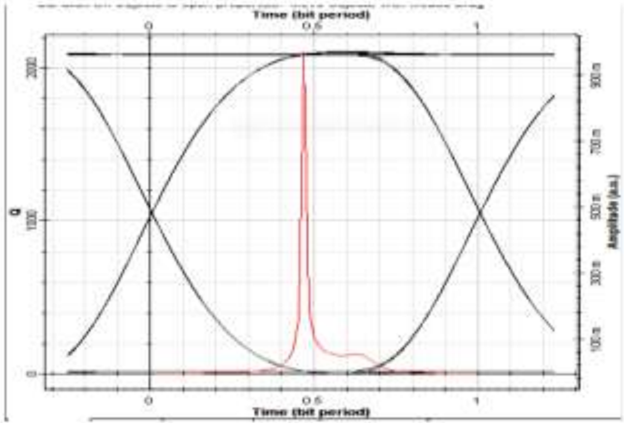


Fig iii: Eye diagram using pre EDFA amplifier at range 5m

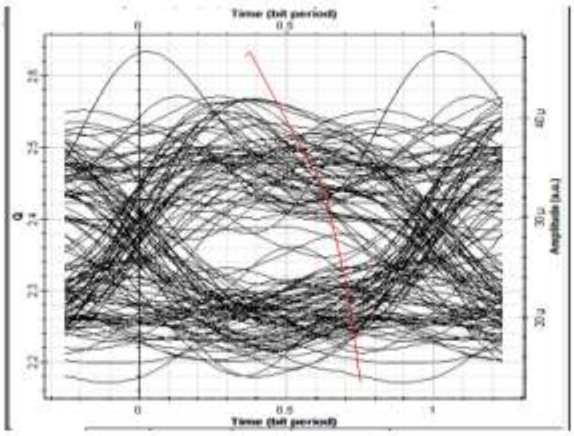


Fig IV: Eye diagram using pre on post EDFA compensation technique at range 125m

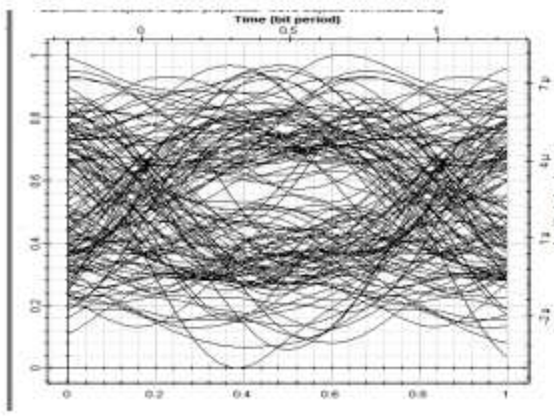


Fig v: Eye diagram using pre EDFA at range 90m

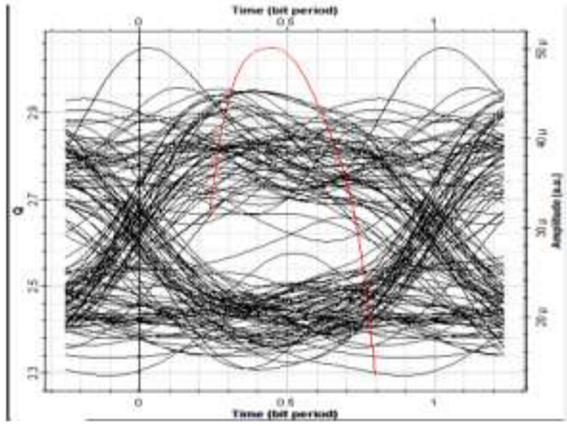


Fig VI: Eye diagram using post EDFA technique atrange85

From Fig. 4 and Fig. 5 it can be seen that to achieve distancesgreater than 50m certain parameters of the system must be changed on the transmitting side, such as increasing the source power, variation in receiver aperture diameter , varying beam divergence and using some amplification techniques.

Based on the results shown in Fig. 4, Fig 5, and Fig 6, it can be concluded that the FSO system has the best performance at receiver aperture diameter 20cm, beam divergence 0.2mrad and using pre on post EDFA compensation technique where it is possible to achieve quality transmission over longer distances for attenuations up to 454dB/km

IV. CONCLUSION

The performance of the FSO system was tested by simulation, and the proposed compensatory strategies reducedor eliminated the impact of various noises on system performance. The proposed strategies significantly improved system performance, with the symmetric compensation strategy proving to be the most effective. Furthermore, scintillation was assessed and approaches were provided to decrease the effect of such elements on FSO performance due to signal loss due to environmental factors such as fog, snow,rain, and haze. Under the influence of external influences, the proposed approaches exhibited significant improvements in signal quality.

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