Free space optics communication system design using iterative optimization

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Abstract- Free Space Optics (FSO) communication provides attractive bandwidth enhancement with unlicensed bands worldwide spectrum. However, the link capacity and availability are the major concern in the different atmospheric conditions. The reliability of the link is highly dependent on weather conditions that attenuate the signal strength. Hence, this study focuses to mitigate the weather and geographic effects using iterative optimization on FSO communication. The optimization maximizes the visibility distance while guaranteeing the reliability by minimizing the Bit Error Rate (BER). The wireless optical communication system is designed for the data rate of 10 Gbps. The performance of the proposed wireless optical communication is compared against the literature in terms of visibility distance, quality factor, BER, and Eye diagram at different atmospheric conditions. The simulation results have shown that the proposed work has achieved better performance.

Keywords – BER; FSO; optical link design; quality factor

I. Introduction

The wireless communication has shown pragmatic development. This increased customer attraction has led to significant demand for high Quality of Service (QoS). The optical communication is not accessible in remote areas because of both the deployment difficulty and the cost-ineffective. Recently, FSO communication has shown an attractive alternative solution that replaces the radio and microwave communication with Gigabits data rate. The light beam loss happens because of the absorption due to molecular diffusion and scattering caused by fog, rain, snow, and haze [6]. The atmospheric turbulence happens because of the scattering, absorption, and dispersion due to fog, haze, mist, snow, and rain. The need for high-speed Internet is significantly growing with the fast expansion of smartphones. The customers can use it on different online applications, audio/video streaming, videoconferencing, online messaging, and web browsing .overall wireless optical communication has tremendous benefits over the RF communication as it has a higher operating frequency and hence better data rate. The aim of this thesis is to provide generalized models for the turbulence and misalign- ment. Also, scintillation mitigation methods are investigated using space diversity and relaying. A performance analysis of selection combining diversity technique over dual- branch FSO system is offered . Free space optical (FSO) communication is a growing technology to handle high data rate and it has very large information handling capacity. FSO communication systems are presented as an available alternative to the fiber optics technology which is capable of full duplex transmission of data, voice and video in certain applications. This free space technique needs only a clear line- of- sight (LOS) path between the transmitter and the remote receiver. Actually, the use of light is a very old technique which was used earlier for signaling purpose. The first wireless optical communication was experimentally tested by Graham Bell. In 1880 Alexander Graham Bell demonstrated the "photo-phone" communication which was modulated by sunlight . The research aim of this thesis is to develop new techniques to improve the performance of free space optics related to optical link in presence of atmospheric turbulence. There are various parameters/phenomena effecting FSO which can be studied and analyzed to improve the performance of FSO under turbulent atmospheric conditions. . Different diversity techniques can be explored and analyzed to find the performance improvement of free space optical communication in various atmospheric turbulence models.

II. PROPOSED ALGORITHM

The FSO has attractive applications including better data rates, better security, cheap network installation, and license-free spectrum. Besides, it has better immunity from the electromagnetic interference because it cannot be detected using the RF meter, it is neither visible nor health hazardous, it can easily achieve very low BER, unlike RF antennas it doesn't have side lobes and the deployment is both cheap and quick. The transmitter part transmits the signal in the wireless media by converting the electrical signal into the optical one using the optical modulator. Then, the optical signal propagates via the wireless medium and it is collected by the receiver and converted into a useful elec- trical signal. The transmitter subsystem consists of a pulse generator, line coder, modulator, optical power meter, spectrum analyzer, switching system, and optical amplifier. On the other hand, the receiver is comprised of optical amplifiers, photodetector, low pass filter, power meter, and BER analyzer. Similar to the optical amplifier used in the transmitter, it improves the received signal strength. The photodetector perceives the received optical signal and it converts it into electrical form. the BER can be calculated from the SNR of the received information.The output of the system is evaluated for three different optical transmission atmospheric conditions with the attenuation values 20 dB/km, 30 dB/km, and 70 dB/km using a BER analyzer. The atmosphere is the gaseous layer that surrounds the planet. Fog is a thick cloud of tiny water droplets suspended in the atmosphere that restricts visibility. On the other hand, Smoke is a visible suspension of particles in the air, typically one emitted from a burning substance, for example, carbon. The Haze is another atmospheric phenomenon where the dust, smoke, and other dry particles make the sky unclear .

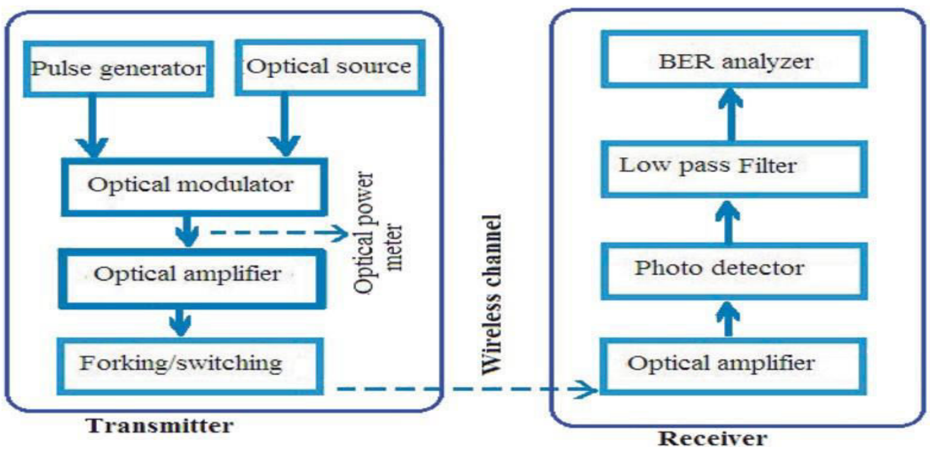

Figure 1. Overview of the optical wireless communication.

The optical amplifier boosts the average power of the laser output and it also amplifies the weak signals before the photodetector detects the optical signal. This reduces the detection noise and hence decreases the BER of the communication. This is a big deal with wireless optical communication because the atmospheric conditions severely affect the signal. It is also well known that amplifiers do not only amplifies the amplitude or phase of the input signal but also introduces some noise. The optimization technique is a mathematical procedure which applies a random starting test parameters to generate ordered improving approximate solutions for a certain problem. The optimization technique proposed in this paper is an iterative optimization that starts with termination criteria and constraint boundaries. The pro- posed iterative algorithm utilizes the problems whose solution fairly constrained by many service requirements and it avoids significant computational downsides. The objective of this study is to maximize visibility distance and minimize error rate while the reliability and data rate are kept guaranteed. The proposed iterative optimization problem is to minimize the BER, given as a function f of N variables. The proposed iterative optimiza- tion is also going to maximize the visibility distance, given as a function g of M variables. Now let's find the minimizer,

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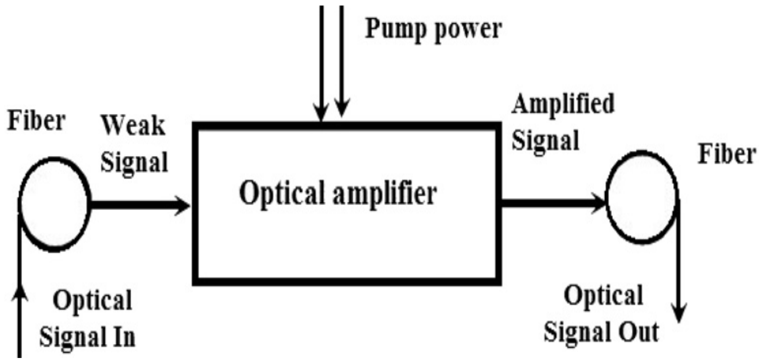

Figure 2. Overview of Optical amplifier.

III. EXPERIMENT AND RESULT

Using this FSO, the end to end optical design is constructed as shown in Figure 3. The optical transmitter is fixed to a data rate of 10 Gbps. It is the n encoded with the NRZ pulse generator. As an optical source, the CW laser is used and it is given 60 dBm of power and 1550 nm wave- length. With this in mind, the proposed visibility distance maximizing and BER minimizing mechanism have evaluated under different atmospheric conditions including Haze, rain, mist, and fog. The Q factor, BER, and received power are evaluated using OptiSystem 16.

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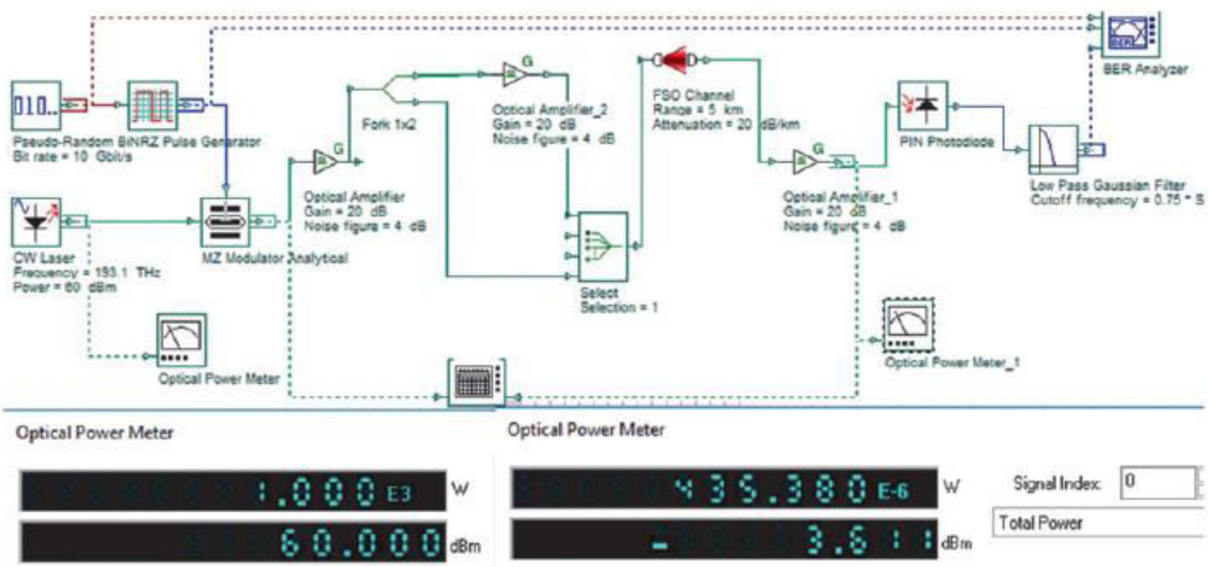

Figure 3.Schematic view of the adaptive FSO design.

Under Haze Atmospheric condition

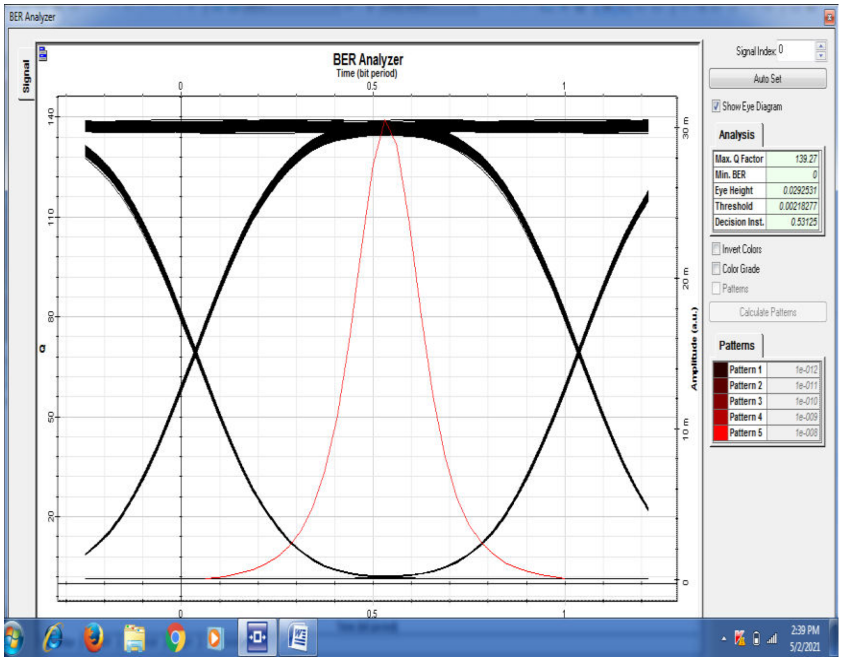

Figure 4. (a)Q factor (b)Received power (c) Eye pattern performances over distance.

The longer the distance the more the Q-factor is decreased because the signal strength decreases with increasing link distance.

Under Rain & Mist atmospheric conditions

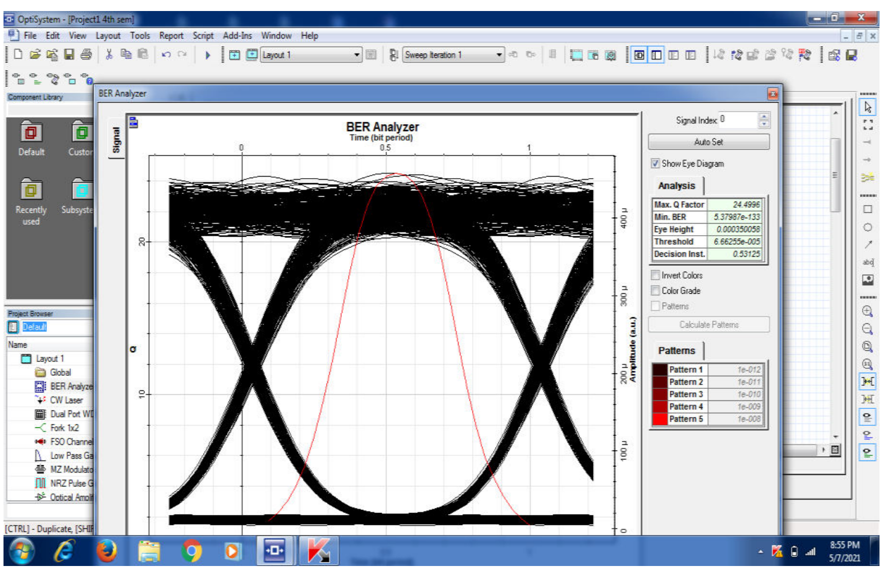

Figure 5. (a) Q factor (b) Received power (c) Eye pattern performance under rainy & mist condition.

This unlicensed spectrum enables attractive distance coverage and it is also characterized 10 Gbps data rate and no error.

Under Fog atmospheric condition

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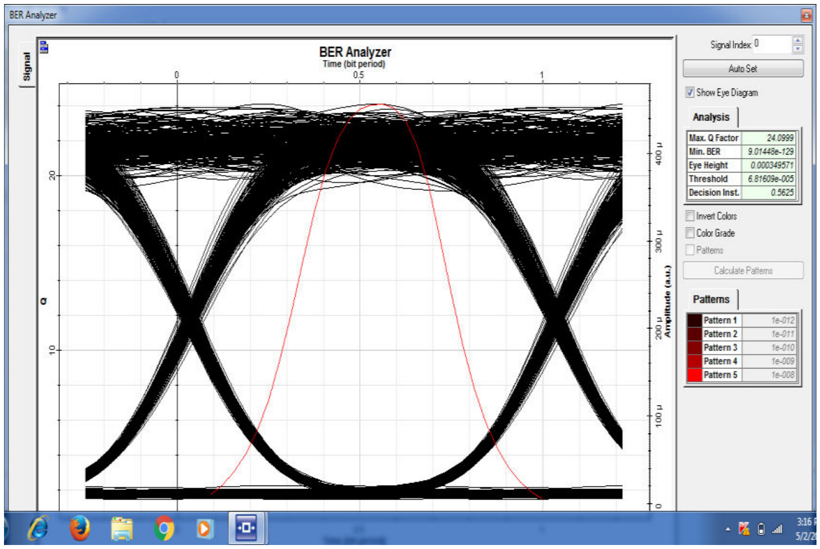

Figure 6. (a)Q factor (b) Received power (c) Eye pattern performance under fog condition.

IV.CONCLUSION

Even though the FSO enables attractive communication characteristics, the wireless link easily deteriorates the optical signal. The data rate and BER are highly weather conditions dependent which severely attenuate the signal. To decrease the atmospheric conditions, this study has proposed an iterative optimization algorithm and an enhanced optical communication link design. The optimized optical link design is evaluated its performance interms of visibilitydistance, qualityfactor, BER, and Eye diagram at hazy, misty, rainy, and foggy atmospheric conditions Keeping the BER, data rate, and Q-factor are greater than or equal to the recent researches, the visibility distance is maximized by advancing the optical link design and by optimizing the optical amplifier length. For any given atmospheric condition. In general, the simulation results have shown that better visibility distance, Q factor, and less BER are achieved at the expense of little system complexity.

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