IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

PERFORMANCE EVALUATION OF VARIOUS MODULATION TECHNIQUES IN FSO COMMUNICATION SYSTEM UNDER DIVERSE WEATHER CONDITIONS

V.Arthi[1] B. Rajesh Kanna[2]

[1]PG Scholar,[2]Associate Professor
[1]Electronics and Communication Engineering,
[1]Alagappa Chettiar College of Engineering and Technology, Karaikudi, India

Abstract: Free space optical communication (FSO) proves to be very effective and efficient technology for wireless communication. This paper basically deals with the designing of FSO systems for various digital modulation techniques. Performance investigation of PSK, QPSK, DPSK modulations in FSO system is analyzed by varying attenuation ranges for several weather conditions including haze, rain, and fog and obtained better Q – factor and minimum BER which is desired for better communication.DPSK is proved to be an effective modulation technique for all kind of weather conditions.

Index Terms - **FSO, bit error rate (BER), Amplitude ShiftKeying (ASK), Phase Shift Keying (PSK), Attenuation**

I. INTRODUCTION

Nowadays, a very high-quality service demand for multimedia services is increasing drastically. Optical fibers have been used for so many years to fulfill this demand. But the shortcoming of these fibers is that it is not suitable for remote areas deployment and enhances the cost of the system. So, an alternative approach to meet the desired requirements is free space optics (FSO) technology.FSO uses optical wireless links to offer point to point communication in outdoor terrestrial regions with clear line of sight (LOS). FSO system has an optical transceiver unit which has a bi-directional functionality. Each unit involves an optical source, telescope which transmits light through free space, which behaves as a communication channel in it, to another telescope and receives the information. Advantages of FSO include high reuse factor, robustness, easily deployable, license free band, no signal interference. FSO system is used for various applications, such as in LAN networks for campus connectivity with Gigabyte Ethernet speeds, in metropolitan area network, spacecraft communication, video surveillance, back-haul for cellular networks like 5G etc. Unfortunately, FSO links are prone to in homogeneities produced by the temperature and pressure in the atmosphere. This causes atmospheric turbulence effect. This results fluctuations in the received signal, called as scintillation effect or turbulence-induced fading. This is analogous to fading in RF system. Due to this, FSO suffers with the drawback of less reliable link connectivity mainly for distances more than 1500 m and is sensitive to various weather conditions.

Free Space Optical Communication

Free Space Optical (FSO) communication or Optical wireless communication(OWC) has emerged as a viable technology for next generation broadband wireless applications in different areas of the long and short haul communications space from links of inter satellite to links of inter building.

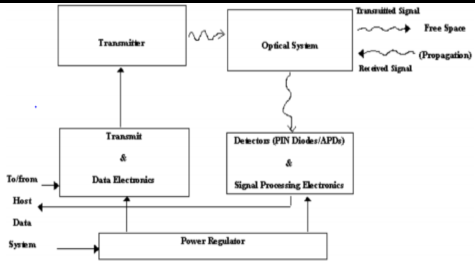


Fig. 1 FSO Communication System

In applying wireless infrared communication, non-directed links, which do not require precise alignment between transmitter and receiver, are desirable. They can be categorized as either line-of-sight (LOS) or diffuse links. LOS links require an unobstructed path for reliable communication, whereas diffuse links rely on multiple optical paths from surface reflections. On the other hand, FSO communication usually involves directed LOS and point-to-point laser links from transmitter to receiver through the atmosphere. FSO communication over few kilometer distances has been demonstrated at multi Gbps datarates.FSO technology offers the potential ofBroadband communication capacity using unlicensed optical wavelengths. However, in homogeneities in the temperature and pressure of the atmosphere lead to refractive index variations along the transmission path. These refractive index variations lead to spatial and temporal variations in the optical intensity incident on a receiver, resulted in the fading. In FSO communication, faded links caused by such atmospheric effects can cause performance degradation manifested by increased bit error rate (BER) and transmission delays.

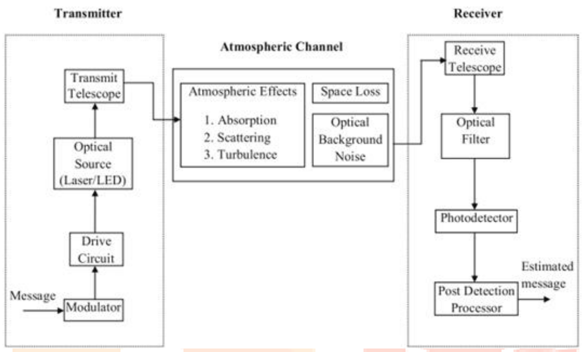


Fig. 2 FSO Communication Link

The basic block diagram of an FSO link comprises of three basic subsystems, viz., transmitter, channel, and receiver.

Transmitter: Its primary function is to modulate the message signal onto the optical carrier which is then propagated through the atmosphere to the receiver. The essential components of the transmitter are (a) the modulator, (b) the driver circuit for the optical source to stabilize the optical radiations against temperature fluctuations, and (c) the collimator or the telescope that collects, collimates, and directs the optical radiations toward the receiver. The most widely used modulation is the intensity modulation (IM) in which the source data is modulated on the irradiance/intensity of the optical carrier. This can be achieved by varying the driving current of the optical source directly with the message signal to be transmitted or by using an external modulator.

Channel: Since the FSO communication channel has the atmosphere as its propagating medium, it is influenced by unpredictable environmental factors like cloud, snow, fog, rain, etc. These factors do not have fixed characteristics and cause attenuation and deterioration of the received signal. The channel is one of the limiting factors in the performance of FSO system.

Receiver: Its primary function is to recover the transmitted data from the incident optical radiation. It consists of a receiver telescope, optical filter, photo detector, and demodulator. The receiver telescope collects and focuses the incoming optical radiation onto the photo detector. The optical filter reduces the level of background radiation and directs the signal on the photo detector that converts the incident optical signal into an electrical signal. The advantages of FSO are low BERs, absence of side lobes, deployment of FSO systems quickly, No Fresnel zone necessary and low maintenance.

Atmospheric Weather Conditions*:* Atmosphere is the medium of transmission for a FSO link. Attenuation caused by it depends upon several conditions. Weather conditions are the main cause of attenuation. The region in which a link is being established has some specific weather conditions so that the preceding knowledge of attenuation can be gained; for example, fog and heavy snow are the two primary weather conditions in temperate regions. In tropical regions, heavy rain and haze are two main weather conditions and have major effect on the availability of FSO link in that region.

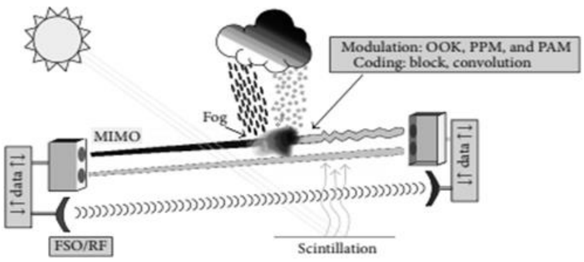


Fig. 3 Atmospheric effects on FSO system

Fog: Fog substantially attenuates visible radiation. Optical beam of light is absorbed, scattered, and reflected by the hindrance caused by fog. Scattering caused by fog, also known as Mie scattering, is largely a matter of boosting the transmitted power.

Rain: Rain attenuation exists due to rain fall and is a nonselective scattering. This type of attenuation is wavelength independent. Rain has the ability to produce the fluctuation effects in laser delivery. The visibility of FSO system depends upon the quantity of the rain. In case of heavy rain, water droplets have solid composed and it can either modify the optical beam characteristics or restrict the passage of beam as optical beam is absorbed, scattered, and reflected.

Haze: Haze particles can stay longer time in the air and lead to the atmospheric attenuation. So, attenuation values depend upon the visibility level at that time. There are two ways to gather information about attenuation for checking the performance of FSO system: first, by installing system temporary at the site and check its performance and, second, by using Kim and Kruse model.

Smoke: It is generated by the combustion of different substances like carbon, glycerol, and household emission. It affects the visibility of transmission medium.

Clouds: Cloud layers are main part of earth atmosphere. The formation of clouds is done by the condensation or deposition of water above earth's surface. It can completely block the fractions of optical beam transmitted from earth to the space. The attenuation caused by clouds is difficult to calculate because of the diversity and in homogeneity of the cloud particles.

Snow: Snow has larger particles which causes the geometric scattering. The snow particles have impact similar to Rayleigh scattering.

11. SIMULATION SETUP

Phase Shift Keying

The PSK is one kind of digital modulation method. This kind of method is used to transmit data by modulating otherwise changing the phase of the carrier signal which is known as a reference signal. The digital data can be represented with any kind of digital modulation method by using a limited number of separate signals. This kind of modulation method uses a limited number of phases where each phase can be assigned with binary digits. Generally, every phase encodes an equivalent number of bits. Every bit pattern forms the symbol that is denoted by the exact phase. The PSK method can be represented by a convenient method namely constellations diagram. In this kind of communication, the points of the constellation can be selected are generally placed by uniform angular spacing in the region of circle. So that utmost phase separation can be offered among nearby points & therefore the best protection to corruption. These are arranged in a circle so that they can all be transmitted by similar energy.

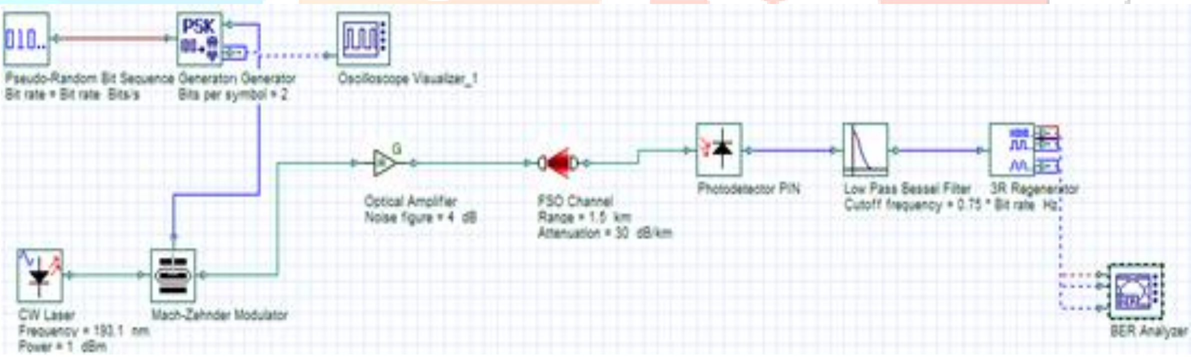


Fig. Simulation of PSK under various weather conditions

Quadrature Phase Shift Keying

The QPSK is a variation of BPSK, and it is also a Double Side Band Suppressed Carrier (DSBSC) modulation scheme, which sends two bits of digital information at a time, called bigits. Instead of the conversion of digital bits into a series of digital stream, it converts them into bit pairs. This decreases the data bit rate to half, which allows space for the other users. The QPSK Modulator uses a bit-splitter, two multipliers with local oscillator, a 2-bit serial to parallel converter, and a summer circuit. Following is the block diagram for the same. At the modulator's input, the message signal's even bits (i.e., 2nd bit, 4th bit, 6th bit, etc.) and odd bits (i.e., 1st bit, 3rd bit, 5th bit, etc.) are separated by the bits splitter and are multiplied with the same carrier to generate odd BPSK called PSK_I and even BPSK called PSK_Q.

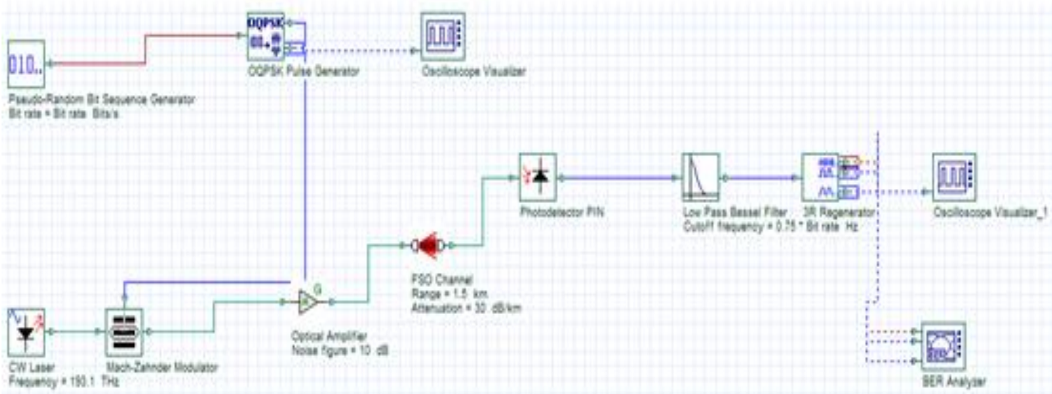


Fig. Simulation of QPSK under Various Weather Condition

Differential Phase Shift Keying

In Differential Phase Shift Keying DPSK the phase of the modulated signal is shifted relative to the previous signal element. No reference signal is considered here. The signal phase follows the high or low state of the previous element. This DPSK technique doesn't need a reference oscillator.

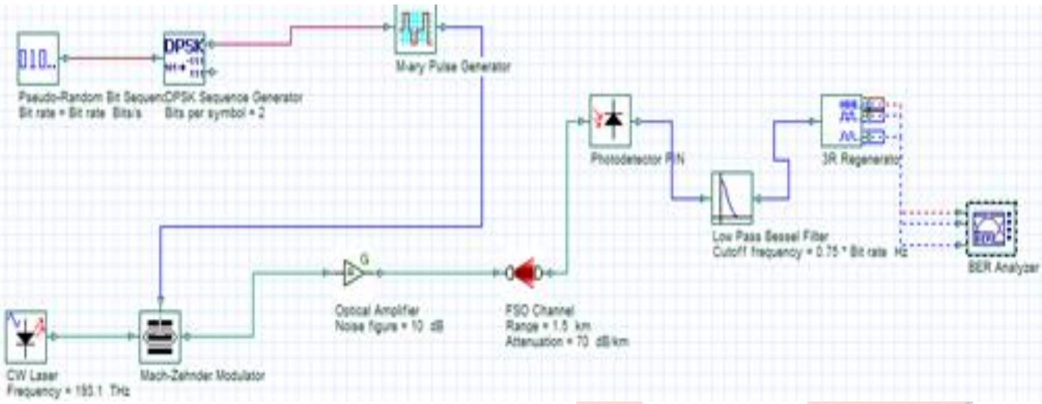


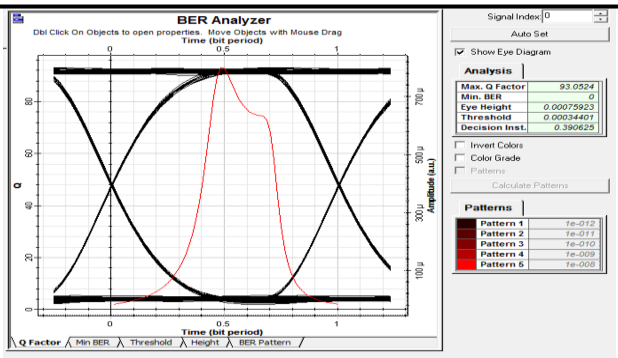
Fig. Simulation of DPSK based FSO under various weather conditions

111. Results and Discussion

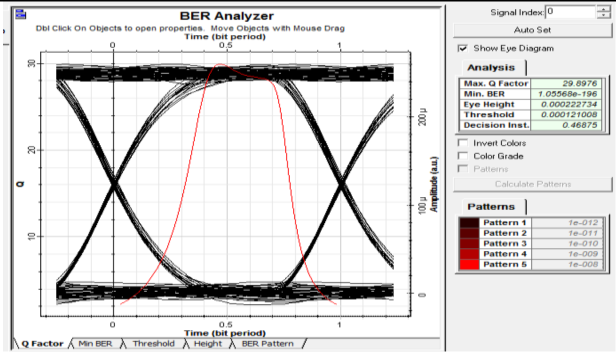
In this section, comparison of various modulation techniques under diverse weather conditions is presented. Table 2 shows the Q-factor and BER for PSK, QPSK and DPSK in FSO with LOS = 1500m. Fig. 8 (a) to (c) show the eye patterns of PSK in FSO with LOS = 1500m for diverse weather conditions viz rain, haze and fog. Fig. 9 (a) to (c) show the eye patterns of QPSK in FSO with LOS = 1500m for diverse weather conditions viz rain, haze and fog. Fig. 10 (a) to (c) show the eye patterns of PSK in FSO with LOS = 1500m for diverse weather conditions viz rain, haze and fog.

Table 2 Q-factor and BER under diverse weather conditionfor PSK, QPSK and DPSK in FSO with LOS = 1500m.

Sl. No.	Modulation Technique	Weather Condition	Attenuation (dB/Km)	Q-Factor	BER
1.	PSK	Rain	30	50.9812	0
		Haze	20	61.2633	0
		Fog	70	82.1668	0
2.	QPSK	Rain	30	65.2524	0
		Haze	20	69.4322	0
		Fog	70	74.7115	0
3.	DPSK	Rain	30	20.0453	0
		Haze	20	69.082	0
		Fog	70	74.3265	0



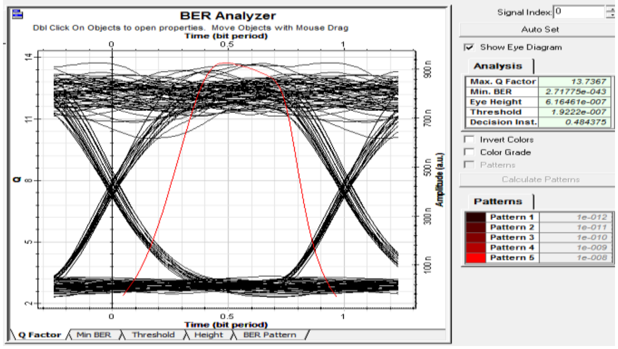
(a)



(b)

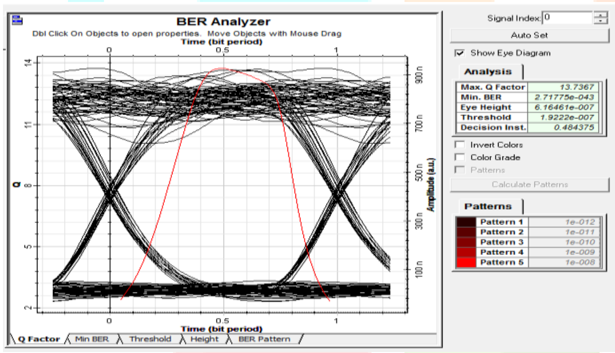
Table 1Parameters of FSO System

Atmospheric Conditions	Attenuation (dB/Km)
Rain	6-30
Haze	10.92-20.68
Fog	70

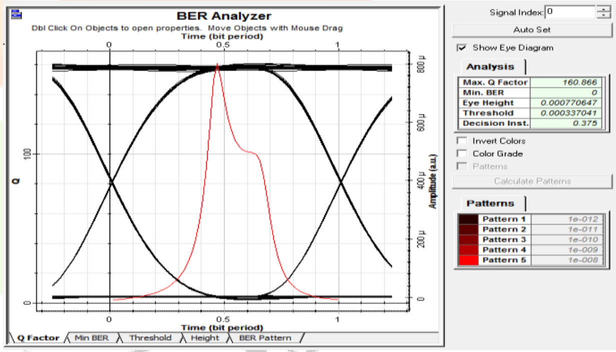


(c)

Fig. 8 (a) to (c) show the eye patterns of PSK in FSO with LOS = 1500m for diverse weather conditions viz rain, haze and fog.

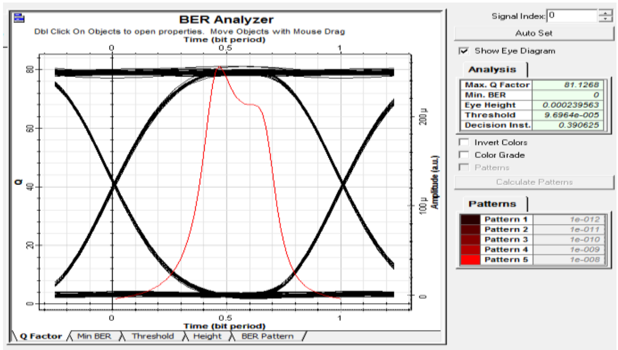


(a)

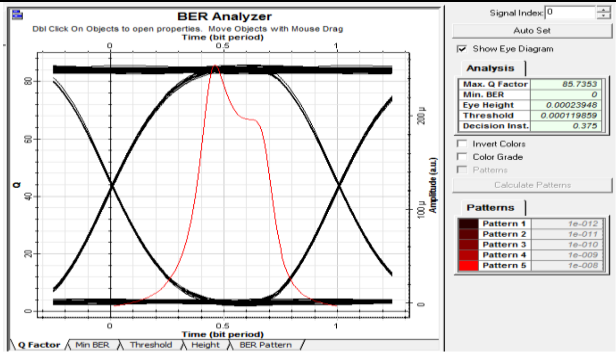


(b)

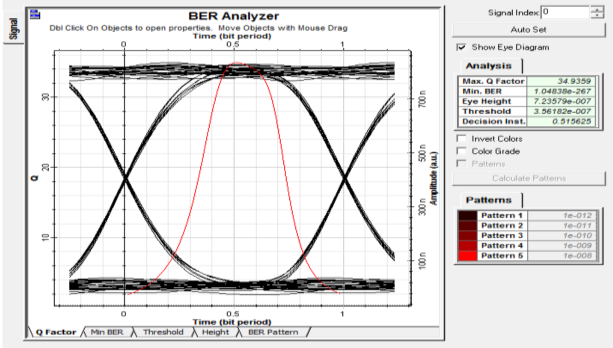
Fig. 9 (a) to (c) show the eye patterns of QPSK in FSO with LOS = 1500m for diverse weather conditions viz rain, haze and fog.



(c)

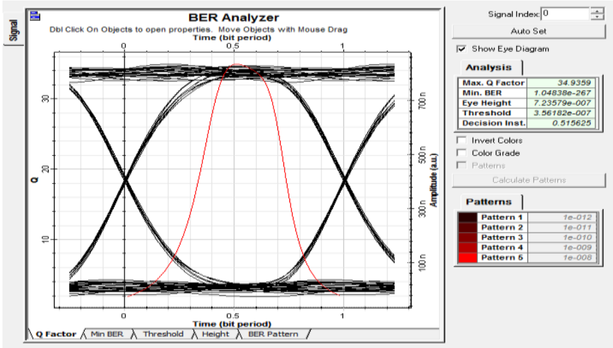


(a)



(b)

Fig. 10 (a) to (c) show the eye patterns of PSK in FSO with LOS = 1500m for diverse weather conditions viz rain, haze and fog.



(c)

Q factor measures the quality of an transmission signal in terms of its signal-to- noise ratio (SNR) and it is the difference between the mean values of the signal levels for a "1" and a "0" divided by the sum of the noise values at those two signal levels assuming Gaussian noise and the probability of a ‘1’ and ‘0’ transmission being equal (P(1) = P(0) = ½)).The greater that difference is, the higher the Q-Factor and the better the BER performance. BER is the number of bit errors per unit time. It is the number of bit errors divided by the total number of transferred bits during a studied time interval.

1V. CONCLUSION

Performance analysis ofPSK, QPSK and DPSK in FSO system under various weather conditions such as rain, haze, fog is presented for the acceptable Q-factor and BER. For various attenuation ranges corresponds to different weather conditions are fed into free space optical channel and the signal performance is analyzed in terms of Quality factor and BER. Performance analysis shows that DPSK outperforms PSK and QPSKin FSO system under the influence of diverse weather conditions.

.

REFERENCES

[1] Khalighi, M.A. and Uysal, M. (2014), “Survey on Free Space Optical Communication: A Communication Theory Perspective”, IEEE Communications Surveys & Tutorials, No. 16, pp. 2231-2258.

[2] Alzenad, M., Shakir, M.Z., Yanikomeroglu, H. and Alouini, M.S. (2018), “FSO-Based Vertical Backhaul/Front haul Framework for 5G+ Wireless Networks” IEEE Communications Magazine, No. 56, pp. 218-224.

[3] Varotsos, G.K., Stassinakis, A.N., Nistazakis, H.E., Tsigopoulos, A.D., Peppas, K.P., Aidinis, C.J. and Tombras, G.S. (2014), “Probability of Fade Estimation for FSO Links with Time Dispersion and Turbulence Modeled with the Gamma-Gamma or the I-K Distribution”,Optik-International Journal of Light and Electron Optics, No. 125, pp. 7191-7197.

[4] Zhu, X.M. and Kahn, J.M. (2002),“Free-Space Optical Communication through Atmospheric Turbulence Channels” IEEE Transactions on Communications, No. 50, pp. 1293-1300.

[5] Kong, L., Xu, W., Hanzo, L., Zhang, H. and Zhao, C. (2015), “Performance of a Free-Space-Optical Relay-Assisted Hybrid RF/FSO System in Generalized-Distributed Channels” IEEE Photonics Journal, No. 7, pp. 1-19.

[6] Duthel, T., et al. (2006) Quasi-Analytic Synthesis of Non-recursive Optical Delay Line Filters for Reliable Compensation of Dispersion Effects. Journal of Light wave Technology, No. 24, pp. 4403-4410.

[7] Rahim, A., et al. (2012) Finite Impulse Response Filter Using 4-Port MMI Couplers for Residual Dispersion Compensation. Journal of Light wave Technology, No. 30, pp. 990-996.

[8] Ashraf, M. and Ranjan, R. (2018) Tunable Single Pass band Microwave Photonic Filter Based on Direct Generation Technique. 3rd International Conference on Microwave and Photonics (ICMAP), Dhanbad, 9-11 February 2018, pp. 1-2.

[9] Vavoulas, A., Sandalidis, H.G. and Varoutas, D. (2012) Weather Effects on FSO Network Connectivity. IEEE/OSA Journal of Optical Communications and Networking, 4, 734-740.

[10] Nebuloni, R. and Capsoni, C. (2016) Effects of Adverse Weather on Free Space Optics. In: Uysal, M., et al., Eds., Optical Wireless Communications, Signals and Communication Technology, Springer International Publishing, Switzerland, pp. 47-68.

[11] Das, S. and Chakraborty, M. (2016) ASK and PPM Modulation Based FSO System under Varying Weather Conditions. 2016 IEEE 7th Annual Ubiquitous Computing, Electronics & Mobile Communication Conference (UEMCON), New York, NY, 1-7.

[12] Kadhim, Dr.S.A., Shakir, A.A.J., Mohammad, Dr.A.N. and Mohammad, N.F. (2015) System Design and Simulation Using (OptiSystem7.0) for Performance Characterization of the Free Space Optical Communication System. International Journal of Innovative Research in Science, Engineering and Technology, 4, No. 6.

[13] Jain, D. and Mehra, R. (2017) Performance Analysis of Free Space Optical Communication System for S, C and L Band. International Conference on Computer, Communications and Electronics (Comptelix), Jaipur, 1-2 July 2017, pp. 183-189.

[14] Shaina and Gupta, A. (2016) Comparative Analysis of Free Space Optical Communication System for Various Optical Transmission Windows under Adverse Weather Conditions. Twelfth International Multi-Conference on Information Processing, No. 89, pp. 99-106.