Journal of Basic and Applied Engineering Research
p-ISSN: 2350-0077; e-ISSN: 2350-0255; Volume 5, Issue 7; October-December, 2018, pp. 565-572

http://www.krishisanskriti.org/Publication.html

Performance analysis of SAC OCDMA in FSO under different Weather Conditions

Rajvir Kaur[1], Avneet Kaur[2] and Baljeet Kaur[3]

[1,2,3]Dept. of ECE, Guru Nanak Dev Engg. College Ludhiana, India
E-mail: [1]missgrewal24@gmail.com, [2]ece.avneetkaur@gndec.ac.in, [3]baljeet12@yahoo.com

Abstract—*The optical communication has become the most prominent area of research. The massive growth of extensive transmission capacity in networking fields defines that end user requirements for high bandwidth network services is at all-time demand. The upcoming need of telecommunication services is progressing day to day not only for its faster capability purpose but also to achieve high security in optical networks, which is an effective solution for an extensive transmission capacity. Consequently, SACOCDMA technique was introduced as the effect of MAI can be completely eliminated when the code sequences with fixed in-phase cross-correlation are used. In this study, the SAC-OCDMA with Multi diagonal code and diagonal double weight code with FSO is implemented and analyzed under various weather conditions such as haze and rain. Ten simultaneous users with 5Gbps data rate are evaluated in the system. The Effect of transmitted power and beam divergence are considered and tested in terms of Q- factor and BER.*

Keywords*: Optical Communication, Fiber Optical, Fiber Space Optics, Optical Code Division Multiple Access, SAC OCDMA, BER, Attenuation.*

1. INTRODUCTION

In FSO, the light beam is modulated through atmosphere to accomplish the communication. The FSO is widely applicable for purpose of disaster recovery management in order to create temporary connections. FSO communication process is exposed to certain issues by distortions occurring in the atmosphere. The FSO design development should be done by considering the environmental conditions as a major factor. The environmental conditions such as clouds, rain, and clear weather have highest impacts on FSO links. The conditions with high visibility level and low attenuation fall under the category of clear weather. The content with low visibility, high moisture and high attenuation gauges that the atmosphere is quite misty with dense clouds. The little droplets of water indicate the rainy season. Due to the variations in environment a constant degradation with respect to the power losses can be seen in optical communication.

OCDMA is able to exploit the optical fibre bandwidth and is one of the most promising technologies that use CDMA. OCDMA uses optical components that are active or passive such as routing, switching, multiplexing the signal to encode and decode the signals. It is a type of internetworking and multiplexing technologies.

The OCDMA technique worked successfully in the wireless network and hence was adapted here also. If the destinations are different, the users can access the channel without waiting using the CDMA method. According to the theoretical analysis of OCDMA, the main reason for the degradation of the performance was the multiple access interference [4]. Consequently, Spectral Amplitude Coding- OCDMA (SAC-OCDMA) technique was introduced as the effect of MAI can be completely eliminated when the code sequences with fixed in-phase cross-correlation are used. This elimination is realized by using balanced detection. Nevertheless, the performance of the system is still limited by the PIIN noise. The effect of PIIN is proportional to the square of photocurrent so by increasing the optical power received, the performance of the system cannot be improved. Hence, a detection technique named as Spectral Amplitude Direct Decoding Technique is proposed to suppress the effect of PIIN [5].

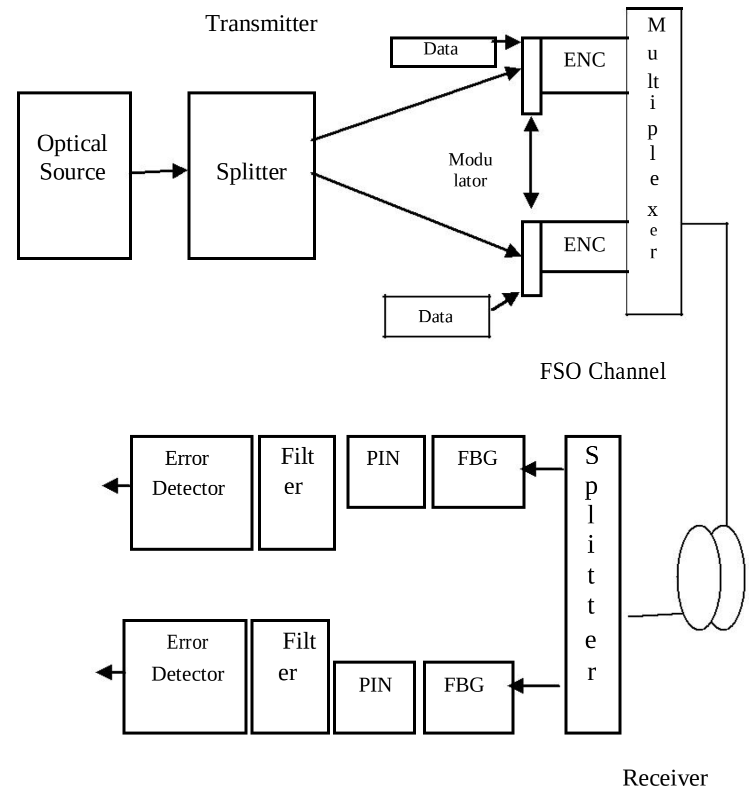

Figure 1: Block diagram of SAC-OCDMA

The transmitter of SACOCDMA consists of optical source, splitter, data generator, modulator and multiplexer. The main components of the SACOCDMA receiver are FBGs, PIN photodiodes, Filters and error detectors. FBG is used as an encoder which works in transmission and uses a broadband source and filters out everything except the frequencies present in the spectral code of the users. All the users in the system share the same optical band width and content frequency elements from the same band, they access the channel asynchronously and without coordination. The light field reflected from an FBG will be spectral encoded onto an address code.

An N × 1 coupler is used to combine all signals onto one fiber to the Central Office (CO). The figure illustrates the balance detector used as receiver in SAC OCDMA. MAI is eliminated using balanced detection.

SAC-OCDMA FSO communication link is used at many places for many services. The detailed description is given below:

- Outdoor wireless access: It can be used by wireless service providers for communication and requires no for using the SAC-OCDMA FSO as it is required in case of microwave bands.
- Storage Area Network (SAN): SAN is basically formed by SAC-OCDMA FSO links. This network provides access to consolidated, block level data storage.
- Last-mile access: To lay cables of users in the last mile is very costly for service providers as the cost of digging to lay fibre is so high and it would make sense to lay as much fibre as possible. The implementation of SAC-OCDMA FSO along with other networks can be used to solve such problem. It is also used for bypassing local-loop systems.
- Enterprise connectivity: Installation of SAC-OCDMA FSO system isvery easy. This feature makes it appropriate for connection of LAN segments to connect two buildings or other property.
- Fibre backup: A backup link can also be provided by SAC-OCDMA FSO if any failure transmission through fibre link occurs.

2. RELATED WORK

Gurpreet Kaur, et. al, (2017), SAC-OCDMA stands for Spectral amplitude coded Optical code division multiple access. This technique has become a major area of research in optical communication. With the help of this technique multiple users can access a medium simultaneously without any contention. This technique helps to reduce multiple user interference, it has the capability to provide privacy and security. In this paper execution of SAC-OCDMA with Diagonal twofold weight (DDW) code with FSO correspondence framework is displayed and looked at under changed states of rain and dimness.10 concurrent clients with 5Gbps information rate are assessed in the framework. Impact of transmitted power and bar difference is likewise considered. Results have been figured in view of eye outlines and estimations of Q-factor and BER. With BER maximum distance covered with 10 km of 10−25 under clear weather. The results showed that DDW code was able to do good at lower power values. **Anisha Priyadarshi, et.al, (2017),** According to this paper SAC-OCDMA(Spectral Ampli**t**ude Coded-Optical Code Division Multiple Access) allows some clients to transfer over the same channel at the same time. A code assigned to the each user which is part of the orthogonal codes. The channel examined in this exploration paper is Free Space Optical (FSO) channel FSO has been a zone of concentrate in the field of correspondence on account of the differed preferences it offers. In communication domain, FSO channel offered more realistic model. It has some kind of limitations, which provides it various attenuation for different conditions of weather which might be include rain, fog, clear and haze weather condition. so it is sensitive to the weather condition common in the region. This review paper examined the (BER) Bit error rate for various climate conditions. This paper analyses the Bit Error Rate (BER) for different weather conditions. At the beneficiary side the discovery plot utilized is Single Photodiode Detection (SPD). Utilizing a solitary photodiode diminishes the shot commotion and expands the optical to electrical change. **S. Mostafa, (2015),** In this examination, we have researched the execution of both the Modified-AND discovery procedure and the Single Photodiode Detection strategy (SPD) in Free Space Optics (FSO) under various rain climate conditions utilizing the Diagonal Eigen value solidarity (DEU) code. The SPD system has demonstrated preferred execution over the Modified-AND. At a separation of 1Km in FSO, the SPD gave Bit Error Rate $\mathbf{10^{-12}}$ while changed AND $\mathbf{10^{-7}}$ because of the decrease of optical to electrical transformation process and the quantity of photodiodes utilized in the recipient with the SPD procedure, which lessen the shot commotion created. Numerical investigation for the SPD discovery system in FSO has determined. Furthermore, optiwave ver.7 has been utilized to do the reproduction examination of the two methods. **Majid Moghaddasi, et.al, (2014),** Execution of three diverse Optical Code Division Multiple Access codes to be specific Prime Code (PC), Quadratic Congruence (QC), and Khazani-Syed (KS) code are analyzed in Free Space Optic (FSO) and optical fiber transmission. The reenactment results demonstrate that productivity of a code family is medium-subordinate. While one code family plays out the best in fiber medium, it isn't important that it demonstrations the same in FSO. For example, KS with code weight of 6 gives BER 10-12 at 600 m remove, while different codes can't reach to the limit 10-9 now. Anyway this code indicates weakness against fiber scattering. At 5 km fiber, it gives BER of 10-7, even less then PC with 10-8. In that point KS code with weight 6 achieves the best execution with BER of 10-11. **W.A. Imtiaz, et.al, (2014),** Optical code division different access (OCDMA) gives another measurement to numerous systems, in which every client is assigned a code. This enables every endorser of at the same time get to the medium with no conflict. Be that as it may, concurrent access of numerous clients presents different access obstruction (MAI) which basically disintegrates the execution of OCDMA frameworks. This paper proposed another code called corner to corner twofold weight (DDW) code to raise the execution and cardinality of ghostly abundance coding (SAC) OCDMA frameworks. Execution of our proposed code is assessed utilizing extensive scientific examination taken after by reenactment investigation. Examination of bit mistake rate demonstrates that DDW code alongside single photodiode location method gives effective execution, with included advantages of rearranged plan, huge cardinality and simplicity of usage. **H.S. Mohammed, et.al, (2013),** The wireless systems in Malaysia were influenced by turbulent weather which lead to a large signal fading or attenuation. This paper proposed using the hybrid Subcarrier Multiplying (SCM)-Spectral Amplitude Coding (SAC) Optical Code Division Multiple Access (OCDMA) system based on Multi-Diagonal (MD) code using Free Space Optic (FSO). According to this paper, hybrid system can be used in the mesh network. The hybrid method has been analyzed by the effects of haze and rain attenuations. Also, this paper has description of modulation scheme, atmospheric effects, data security, the FSO mesh network and simulation. Atmospheric effects, data security, the FSO mesh network and simulation. This technique produced Bit-Error Rate (BER) at storm rain and at heavy haze.

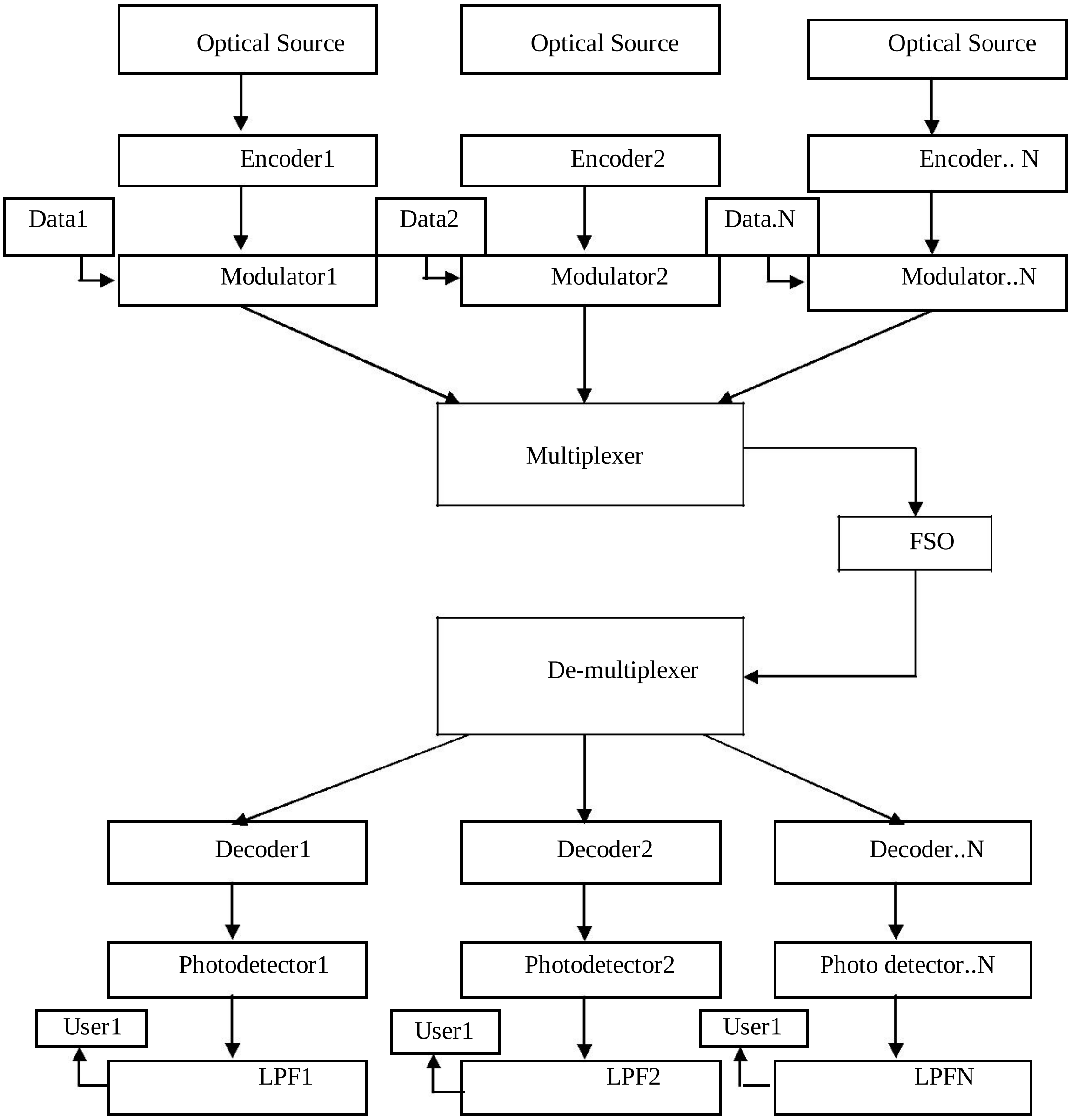

Figure 2: Framework of proposed work

Free Space optical communication utilizes the light to transfer the information instead of fiber. The FSO is quite qualitative way of data transmission but it gets affected from various atmospheric conditions. The weather like rain, haze and fog can leads to the reduction in the visibility and line of sight communication. Atmospheric attenuation of FSO communication system is conquered by fog it also relies upon rain and dust. The attenuation is obtained due to the collaboration of atmospheric attenuation and geometric losses. The particles presented in atmosphere leads to the scattering of the signals and it is also known as dispersion of the energy. Due to the effect of dispersion or scattering, the signal gets diverted from the original target. Geometric scattering is an output of rain drops and snow that is created by large set of molecules having an impact related to the Rayleigh scattering. Additionally, OCDMA system experiences various noises like Phase Intensity Induced Noise (PIIN), thermal noise, shot noise and Multiple Access Inference (MAI).

The above section defines the problem that occurs in OCDMA. Therefore, to resolve the issues, SAC-OCDMA has been developed for optical communication. OCDMA facilitates the multiple users to access a data transmission medium at the same time without any conflict. It is capable enough to process data transmission asynchronously and securely. In this study performance of SAC-OCDMA with

FSO communication channel is analyzed and compared with respect to the various atmospheric conditions like rain and haze. In proposed network structure, simultaneously 10 users with 5 Gbps data rate is analyzed. Along with this, the transmitted power and beam divergence are considered and performance is evaluated in the terms of Q-factor and BER. The steps involved in framework of system are given below:

Step 1. At transmitter side optical source is used to provide the light signal. We will use number of sources according to the weight of code.

Step 2. The optical signal obtained from optical source is encoded individually using number of encoder.

Step 3. Mach Zander modulator is used to modulate the encoded signal.

Step 4. After this signals from different users is multiplexed using multiplexer. Multiplexer combines multiple signals and give one signal in the output.

Step 5. Multiplexed spectral amplitude coded signal travels through free space to the receiver side. In atmosphere (free space) there might be condition of rain, haze or fog. Accordingly the signal will suffer attenuation.

Step 6. At the receiver, received spectrum is split and decoded with respect to user's codes. Each user receives the whole signal and the desired user signal is extracted using FBGs at receiver side.

Step 7. PIN photo detector is used to convert optical signal to electrical.

Step 8. At the end original data is recovered after passing it through Low pass Bessel filter.

3. RESULTS AND EXPERIMENTS

Free space optical communication uses light to transmit data through atmosphere instead of fiber. It founds many applications in the field of communication. FSO can be used in many optical links, such as building to building, ship to ship, aircraft to ground and satellite-to ground. It is the best solution for communication in areas where laying down fiber is a tough job. It is the best alternative for wireless communication systems to transfer high data rate. Moreover it provides license free operation. But communication through FSO has a disadvantage of being affected by weather conditions [6]. Rain, haze and fog can reduce the visibility and effect the line of sight communication.

Rain is the highest attenuation factor in environment for light, so it effects the FSO link also. Rain can reduce visibility to much higher intensity. Rain intensity factor is capable of attenuating laser power and effect the FSO system. Beer's law describes laser power attenuation in the environment as follows:

Where R is the link range, T(R) is the transmittance at range R (km), P(R) is the laser power at source (watt) and β is scattering coefficient ( ).

The figure 3 depicts the graph comparing the attenuation and maximum Q-factor. The y-axis of the graph is the value of Max Q-factor ranging from 0 to 25. The x-axis is the attenuation value scaled from 0 to 19.28 measured in dB/km. Marked at three specific values of attenuation also written in table 1. As it is clearly represented, the graph is non-linearly decreasing. The value of max Q-factor decreases when there is an increase in the value of attenuation. Similarly, figure 4 depicts the variation of attenuation of the system with the value of Min BER i.e. Bit Error Rate. The y-axis of the graph is the value of Min BER represented on the scale of 100E-29 to 100E-01. The x-axis contain the attenuation values from 0 to 19.28 measured in dB/km. As obvious from the graph the value of Min. BER increases with increase in Attenuation value. The graphical data is also depicted in tabular format in the following table 1.

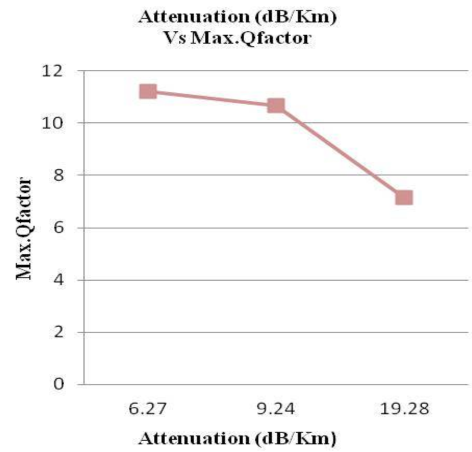

Figure 3 Graph showing the variation in Max Q-factor with attenuation (Rain)

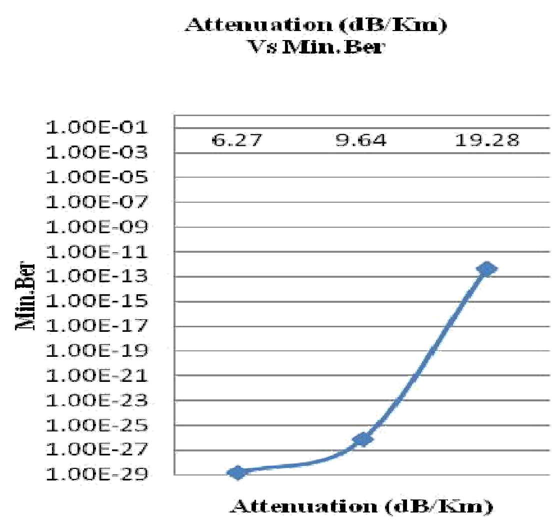

Figure 4 Graph showing the variation in Min BER with attenuation (Rain)

Table 1: Tabular format of Max- Q, Min BER and attenuation comparison (Rain)

Attenuation (dB/km)	Max Q-factor	Min. BER
6.27	11.21	1.41E-29
9.64	10.66	6.39E-27
19.28	7.16	4.01E-13

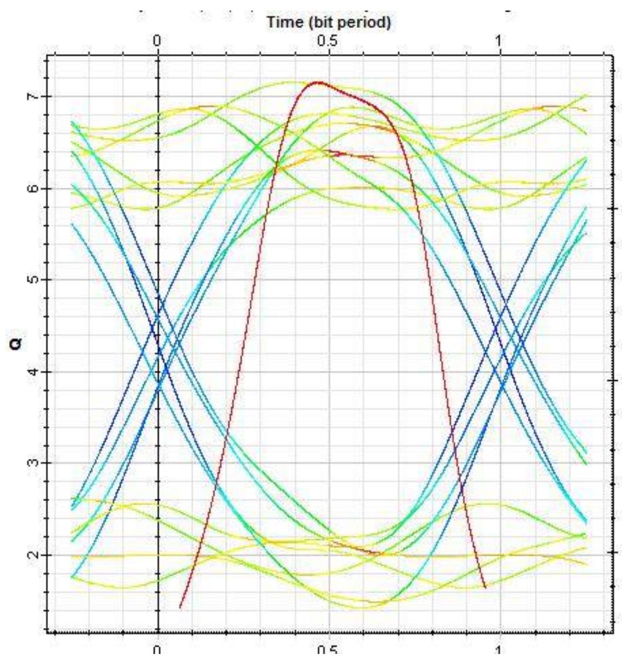

Figure 5 Eye diagram for representing effect of rain

In evaluation of effects of rain on the communication system, the factors considered were to maintain attenuation at 19.28 dB/km and range value of 500 meters. This specification produced the eye diagram depicted in figure 5.

Haze is an atmospheric phenomenon where dust, smoke and other dry particles obscure the clarity of the sky. It results in more particles to stay longer in atmosphere as compared to rain and hence presents more serious degradation on FSO performance. Kim and Kruse model is used for this analysis [1]:

Where,

β= haze attenuation, V= visibility in Km, λ=wavelength in nm and q= size distribution of scattering particles {1.3 for average visibility (6km<V<50km) and 0.585V 1/3 for low visibility (V<6km)}.

The figure 6 depicts the graph comparing the attenuation and maximum Q-factor. The y-axis of the graph is the value of Max Q-factor ranging from 11.5 to 11.59. The x-axis is the attenuation value scaled from 0 to 2.37 measured in dB/km. Marked at three specific values of attenuation also written in table 2.

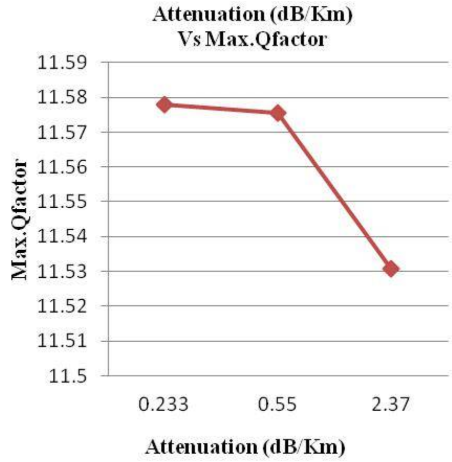

Figure 6: Graph showing the variation in Max Q-factor with attenuation (Haze)

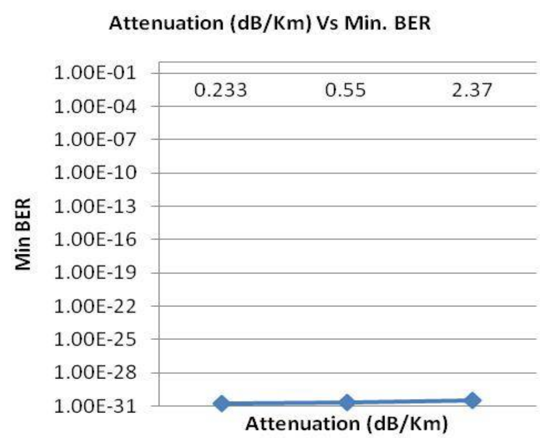

Figure 7 Graph showing the variation in Min BER with attenuation (Haze)

As it is clearly represented, the graph is non-linearly decreasing. The value of max Q-factor decreases when there is an increase in the value of attenuation. Similarly, figure 7 depicts the variation of attenuation of the system with the value of Min BER i.e. Bit Error Rate.

The y-axis of the graph is the value of Min BER represented on the scale of 100E-31 to 100E-29. The x-axis contain the attenuation values from 0 to 2.37 measured in dB/km. As obvious from the graph the value of Min. BER increases with increase in Attenuation value. The graphical data is also depicted in tabular format in the following table 2.

Table 2: Tabular format of Max-Q, Min BER and attenuation comparison (Haze)

Attenuation(dB/km)	Max Q-factor	Min BER
0.233	11.5779	1.96E-31
0.55	11.5755	2.08E-31
2.37	11.5309	3.45E-31

In evaluation of effects of Haze on the communication system, the factors considered were to maintain attenuation at 2.37 dB/km and range value of 500 meters. This specification produced the eye diagram depicted in figure 7.

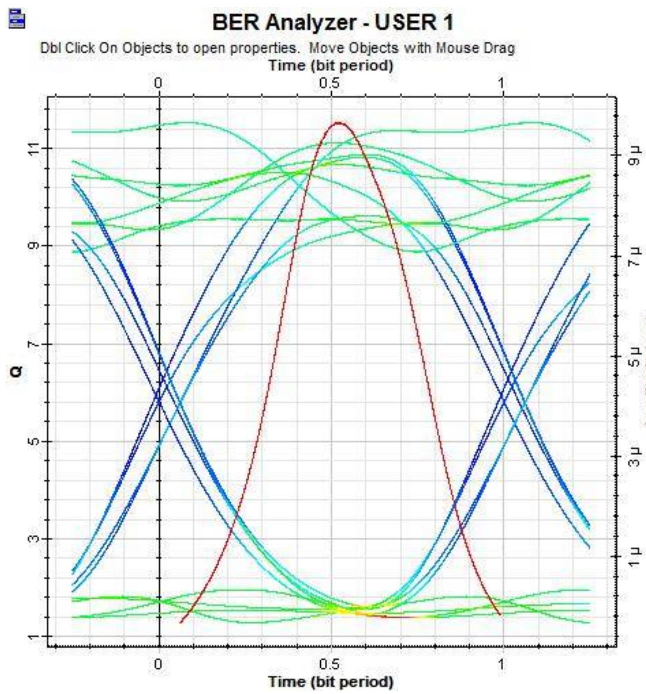

Figure 8: Eye diagram representing the effect of Haze

The figure 8 depicts the graph comparing the Transmission Distance (Tx) and maximum Q-factor. The y-axis of the graph is the value of Max Q-factor ranging from 0 to 14. The x-axis is the Transmission distance value scaled from 0 to 1000 measured in meters. Marked at six specific values of Tx also written in table 5.3. As it is clearly represented, the graph is non-linearly decreasing. The value of max Q-factor decreases when there is an increase in the value of Tx.

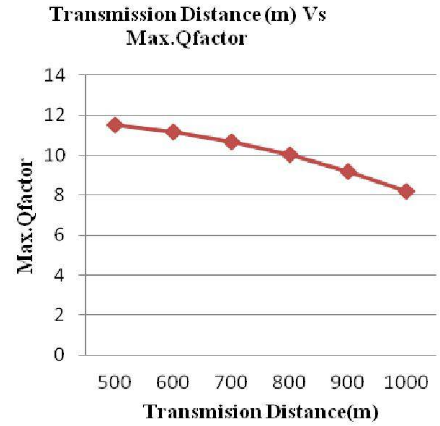

Figure 9: Graph showing the variation in Max Q-factor with Transmission distance

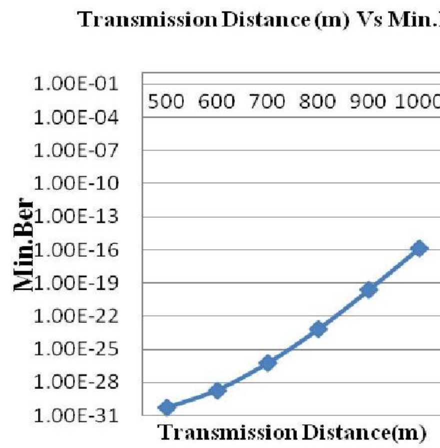

Figure 10 Graph showing the variation in Min BER with Transmission distance

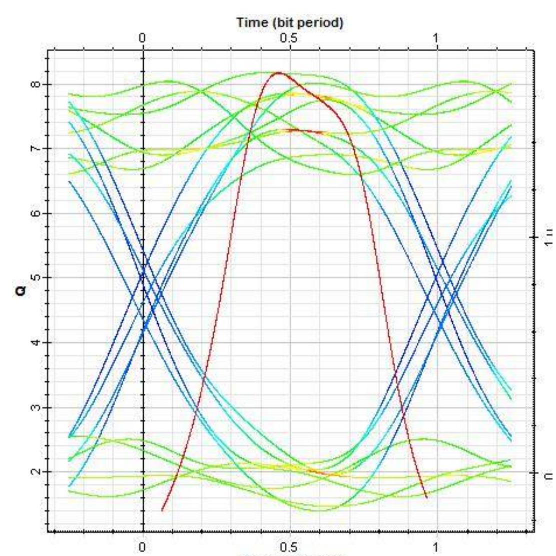

Figure 11: Eye diagram representing the effect of Transmission distance

Similarly, figure 9 depicts the variation of Transmission distance of the system with the value of Min BER i.e. Bit Error Rate. The y-axis of the graph is the value of Min BER represented on the scale of 100E-31 to 100E-01. The x-axis contain the Transmission Distance values from 500 to 1000 measured in meters. As obvious from the graph the value of Min. BER increases with increase in Attenuation value.

In evaluation of effects of Transmission distance on the communication system, the factors considered were to maintain attenuation at 3 dB/km and range value of 1000 meters. This specification produced the eye diagram depicted in figure 10. The graphical data is also depicted in tabular format in the following table 3.

Table 3: Tabular format of Max-Q, Min BER and Transmission distance comparison

Attenuation(dB/km)	Max Q-factor	Min BER
500	11.501	4.92E-31
600	11.184	1.98E-29
700	10.678	5.71E-27
800	10.009	6.53E-24
900	9.164	2.43E-20
1000	8.174	1.48E-16

4. CONCLUSION

In the proposed work, it was evaluated that the climatic factors affect the communication in terms of its BER and Q-factor value. It could be concluded from the analysis, that the weather conditions such as rain and haze deteriorate the quality of signal transmitted. Other factor affecting the communication is the distance between the source and the destination. In the work, it was obtained that when the transmission range from 500 to 1000 meters, value of Q-factor varied from 11.501 to 8.174 and the BER varied from 4.92E-31 to 1.48E-16. Similarly the rain produced variation in Q-factor from 11.21 to 7.16 and the BER variation from 1.41E-29 to 4.01E-13, when the value of attenuation varied from 6.27 to 19.28. The haze produced variation in Q-factor from 11.5779 to 11.5309 and the BER range from 1.96E-31 to 3.45E-31, when the Attenuation varied from 0.233 to 2.37. On the basis of the observed facts and figures, it can be concluded that the proposed work is advantageous over traditional work in terms of having less BER, maximum quality factor over various level of attenuation in the signals. Hence, the communication system is evaluated for the affects and variations produced in system and signal deterioration under the atmospheric conditions.

REFERENCES

[1] Gurpreet Kaur, Gurinder Singh Bal, "*Performance analysis of SAC-OCDMA in free space optical medium using DDW code*", ELSEVIER, pp. 36-42, 2017.

[2] Anisha Priyadarshi, Sudipta Mitra, "*Performance Analysis of SAC OCDMA in FSO system using SPD Technique with APD for Different Weather Conditions*", IOSR Journal of Electronics and Communication Engineering (IOSR-JECE), vol. 12, pp.7-12, 2017.

[3] S. Mostafa, A.N.A. Mohamed, F.E. Abd El- Samie, A.N.Z. Rashed, "*Comparison Between the Performances of Different Detection Techniques in Free Space Optic*"*s*, IJRECE, 2015.

[4] Majid Moghaddasi, Saleh Seyedzadeh, Siti Barirah Ahmad Anas, "*Optical Code Division Multiple Access Codes Comparison In Free Space Optics and Optical Fiber Transmission Medium*", IEEE, pp. 181-184, 2014.

[5] W.A. Imtiaz, N. Ahmad, "*Cardinality enhancement of SAC OCDMA systems using new diagonal double weight code*", International Journal of Communication Networks and Information Security, vol.6, 2014.

[6] H.S. Mohammed, S.A. Aljunid, H.A. Fadhil, T.H. Abd, "*Impact of Attenuation on the Hybrid Sub-carrier Multiplexing SAC OCDMA-FSO System*", IEEE, 2013.

[7] R. Li, A. Dang, "*A Novel Coherent OCDMA Scheme over Atmospheric Turbulence Channels*," IEEE, pp. 1-4, 2017.

[8] R. K. Zakiah Sahbudin, M. Kamarulzaman, S. Hitam, "*Performance of SAC OCDMA-FSO communication systems,*" ELSEVIER, pp. 1-3, 2012.

[9] Hamza M. R. Al-Khafaji ; S. A. Aljunid ; Hilal A. Fadhil, "*Performance enhancement of SAC-OCDMA system using modified-AND subtraction detection*", 2011 IEEE International Conference on Computer Applications and Industrial Electronics (ICCAIE), pp., 2011.

[10] C. B. M. Rashidi, S. A. Aljunid, F. Ghani, Hilal A. Fadhil, M.S. Anuar, "*Development of Codes with Non-Zero In-Phase Cross Correlation Code for SAC-OCDMA Systems*", 2012 IEEE Symposium on Business, Engineering and Industrial Applications, pp. 186-190, 2012.

[11] Thanaa Hussein Abd, S. A. Aljunid, Hilal Adnan Fadhil, Ahmad, R. A., N. M. Saad, "*Suppression of the Phase Induced Intensity Noise Based on the Dynamic Cyclic Shift Code for SACOCDMA Access Networks*", IEEE, pp. 1-5, 2011.

[12] Urmila Bhanja, Alamasety Swati, Arpita Khuntia, "*System design for a SAC OCDMA-FSO Network*", IEEE, pp. 454-458, 2017.

[13] Hamza M. R., Al-Khafaji, S. A. Aljunid, Hilal A. Fadhil, "*Spectral Efficiency of Unipolar SAC–OCDMA System Considering Noise Effects*", IEEE, pp. 218-222, 2011.

[14] C. B. M. Rashidi, S. A. Aljunid, Hilal A. Fadhil, M. S. Anuar, "*Encoder-Decoder Design for SAC-OCDMA using Flexible Cross Correlation (FCC) Code Algorithms*", IEEE, pp. 166-168, 2013.