High Speed, Long Reach OCDMA-FSO Transmission Link Employing FBG Encoder Under Various Atmospheric Conditions and Power Levels

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Abstract. *The FBG encoded signal is transmitted over the free space optical link under different atmospheric turbulences such as clear weather, haze and fog weather. In this paper, the 5 Gbps Fiber bragg grating(FBG) encoder based multi channel Optical CDMA over Free space optics communication(FSO) system is carried out under various atmospheric conditions such as clear weather, fog and haze weather conditions. The system performance is best in terms of quality factor, bit error rate (BER) and at received power of -48 db when the clear weather attenuation is considered and degrade in case of the haze and worst in case of fog weather. The system analyzed at various distances. Also, the simulation of FBG based OCDMA-FSO system at different number of channels and various power levels is carried out which shows that there is tradeoff between the system BER and power levels and system gives optimized performance at -40 MW power.*

Keywords: OCDMA, FSO, Multiple Access Interference (MAI) , Bit error rate (BER)

I. INTRODUCTION

Optical code-division multiple-access (OCDMA) has been developed nowadays as an alternative technology to time and frequency multiplexing for next generation reliable optical networks[1]. Furthermore, OCDMA offers very strong security in physical layer. Due to these various reasons, OCDMA is being established as one of the most important technologies for providing support to many users in shared media at same time[2,3]. FSO is an optic technology that transmists light in free space to provide data transmission between two points[4,5]. The technology is so much useful where the physical connectivity by means of cables is not practicable [6,7]. FSO communication has many advantages over optical fiber communication and terrestrial microwave communication because of high carrier frequencies, data rate, capacity[8]. In FSO performance examination, it is very important to take various FSO parameters into the consideration. These parameters can be divided into various parts: internal and external parameters[9]. In recent years, OCDMA over FSO communication system has become very efficient form of communication in optical wireless communication system due to its high data rate, minimum bit error rate (BER) and security[10,18]. [11] presented a work that the various atmospheric conditions are tested in FSO communication. [12] propesed a work that 2.5 Gbps signal is generated with the NRZ modulation. [13] reviewed the concepts which comprises of challenges a system designer has to consider on implementing of FSO system and atmospheric effects are also studied. [14] presenting a demonstration of fading effective FSO system using simulative bed test with FSO link of acceptable BER with the high data rate of 2.5 Gbps. [15] proposed a view to calculate the quality of transmission of data using Wavelength Division Multiplexing.

FSO communication system provide effective optical connectivity[16]. FSO system has very high accessibility to provide high capacity links to businesses[17]. In this paper we propose the simulative OCDMA with free space optical communication system reported in Section 2. The simulation results have been discussed in Section 3. The conclusion of the simulative results is presented in Section 4.

II. EXPERIMENTAL SETUP:

The 4-user OCDMA over FSO communication system is given in figure1 and 5 Gbps signal is generated through the white light source and is modulated by means of Mech-zender modulator and then sends it to the FBG encoder. The system is based upon spectral-amplitude-coding of broadband optical sources via FBG encoder/decoder. The design illustrates a 4-user spectral-amplitude-coded OCDMA transmitting the data. In designed system based on FBG encoder/decoder, the series of FBGs are implemented for controlling the amplitude spectra of the coherent optical signals. For FBG encoding, each user of OCDMA system is being assigned a unique signature code sequence. For this system we have been implemented the 4 × 4 Hadamard matrix codes In Free space optics, the simulation has been done in various environments such as clear weather (0.1 db/km), haze weather (4 db/km) and fog weather condition (20db/km). At receiver end, the signal is photo detected and the data recoverd successfully.

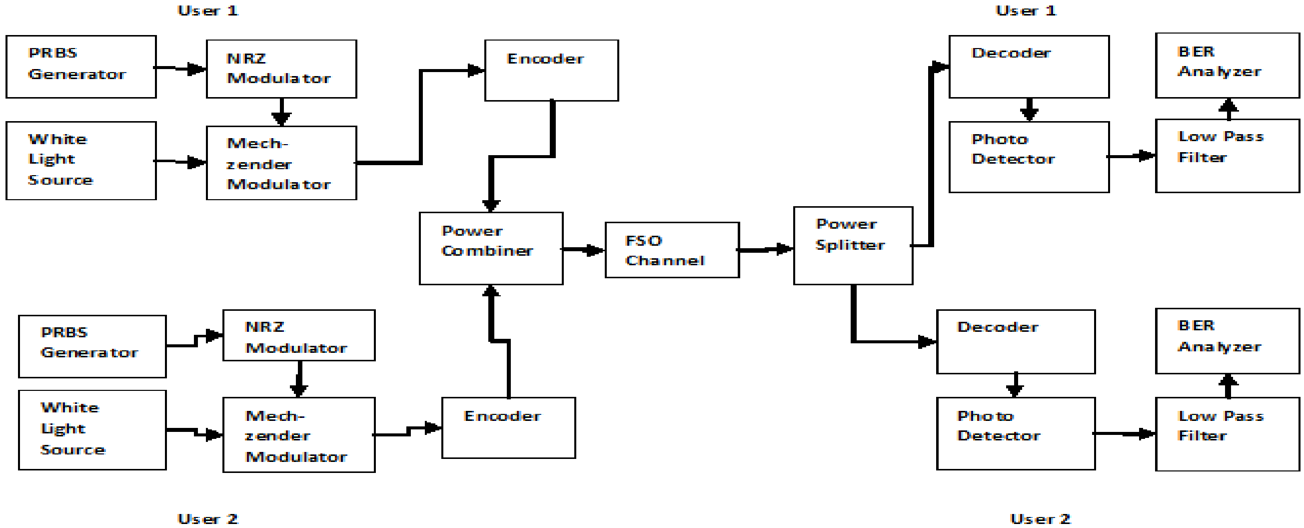


Fig1. Simulation setup of FBG based OCDMA-FSO Communication system

III. RESULTS AND DISCUSSIONS:

The analysis are performed by observing two cases: case (I) demonstrates the performance investigation of FBG based OCDMA-FSO system under various atmospheric conditions, case (II) investigates the designed system with various power levels on designed system. The system are implemented with the Optisystem 14.0 software.

Case I: To investigate the performance of FBG based OCDMA-FSO system under various atmospheric conditions:

The performance analysis of the FBG based OCDMA-FSO system in terms of BER, Q-factor, eye diagram and power spectrum analyzers are given below:

Table1. Bit Error Rate Analysis of designed system under different atmospheric conditions at various distances:

Distance	Clear weather attenuation(0.1db/km)	Haze weather attenuation(4db/km)	Fog weather attenuation(20db/km)
0.1 km	$10e^{-30}$	$10e^{-25}$	$10e^{-18}$
0.5 km	$10e^{-25}$	$10e^{-15}$	$10e^{-14}$
1.0 km	$10e^{-20}$	$10e^{-14}$	$10e^{-11}$
3.0 km	$10e^{-16}$	$10e^{-9}$	$10e^{-4}$
5.0 km	$10e^{-12}$	$10e^{-4}$	$10e^{-2}$

The table 1 and table 2 gives the measure of the BER and Q-factor values of system under various atmospheric conditions at various distances.

When the Free space optics (FSO) channel is set to attenuation of 0.1 db/km and aperture diameter of 5 m then it is said to be the clear weather attenuation and if the attenuation is set to be 4 db/km and aperture diameter is 4 m then it is said to be a haze condition. Similarly, if attenuation of the channel is 20 db/km and diameter is 2 m then it is said to be fog weather.

Figure 2 gives the BER performance analysis of three atmospheric conditions. From the figure, we can clearly see that the clear weather attenuation responds to a better performance and continues sending the signal upto 5 km and so on where as the signal degrades in case of haze weather after 4 km and 3 km in fog weather condition. Figure 3 represents that the clear weather attenuation has the high q-factor upto 5 km as compared to the haze and fog condition.

Table2. Q-Factor of designed system under different atmospheric conditions at various distances:

Distance	Clear weather attenuation	Haze weather attenuation	Fog weather condition
0.1 km	12	10	9
0.5 km	10	8	7
1.0 km	9	7	6
3.0 km	8	5	0
5.0 km	7	0	0

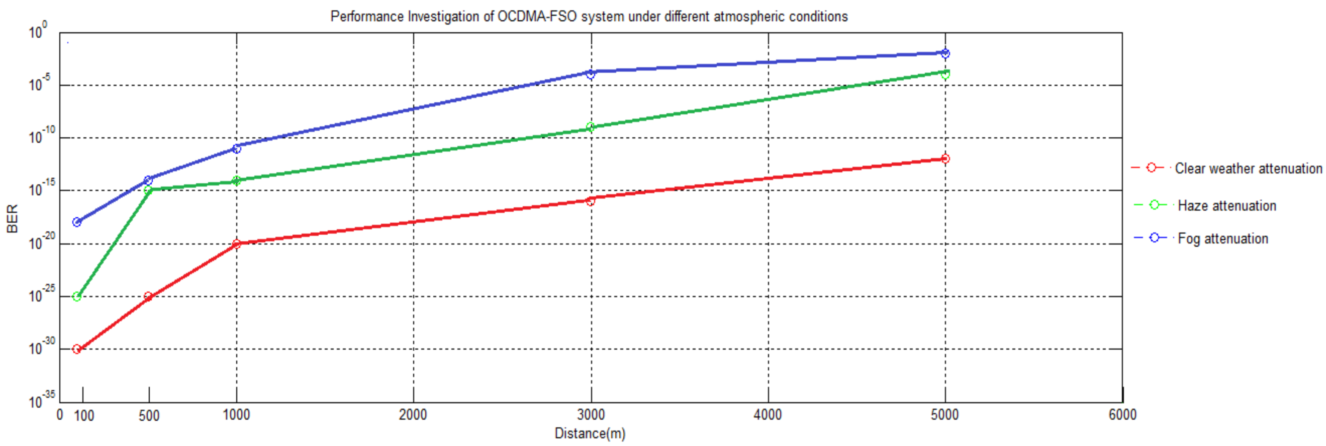


Fig 2. BER Analysis of FBG based OCDMA-FSO system under various atmospheric conditions.

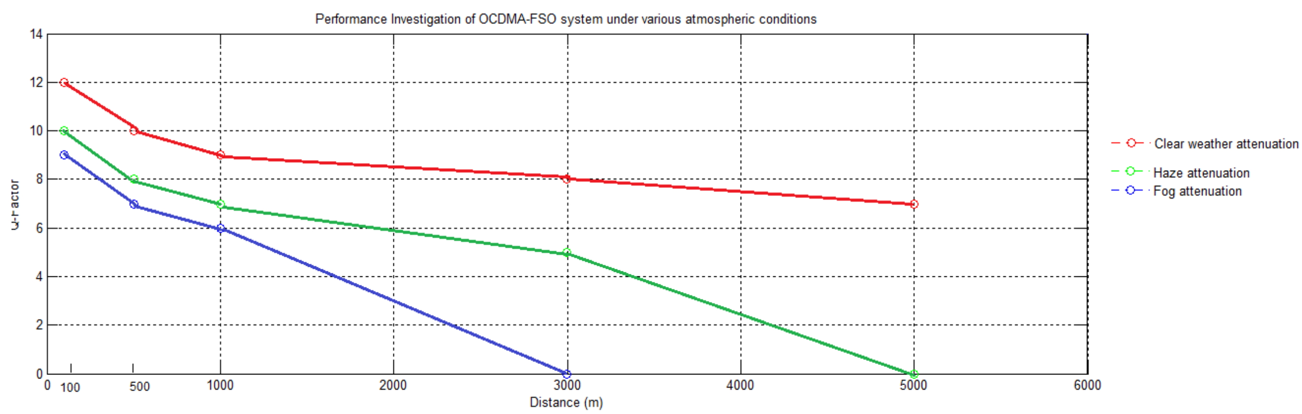
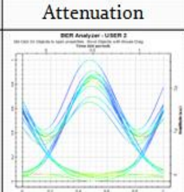
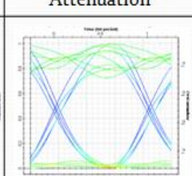
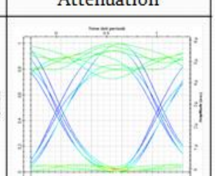
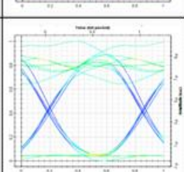
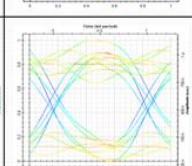
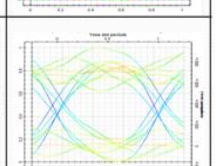


Fig 3. Q-Factor Analysis of FBG based OCDMA-FSO system under various atmospheric conditions.

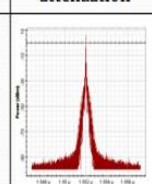
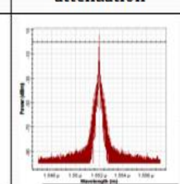
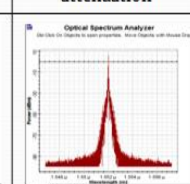
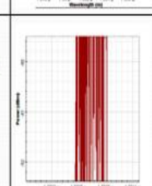
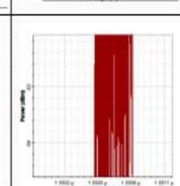
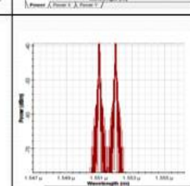
The eye diagrams shown in table 3 clearly depict that in clear weather, system gives us much better performance with a larger eye opening. The vertical distance between the top of the eye opening and the peak signal level represents the degree of distortion. So, the analysis are given below:

Table3. Eye Diagram Analysis FBG based OCDMA-FSO system under various atmospheric conditions.

Users	Eye Diagram		
	Clear weather Attenuation	Haze weather Attenuation	Fog weather Attenuation
User 1			
User 2			

The power spectrum analysis in table 4 represents that the power is fluctuating in the haze and fog weather conditions whereas in clear weather, there is no power fluctuate, and proper power spectrum has carried out. So, system performance is best when clear weather attenuation is considered and results degrade in fog and haze condition.

Table4. Power Spectrum Analyzer of FBG based OCDMA-FSO system under various atmospheric conditions.

Power Spectrum	At Haze weather attenuation	At Fog weather attenuation	At clear weather attenuation
Power Spectrum at Encoder			
Power Spectrum at Decoder			

Case II: To investigate the performance of FBG based OCDMA-FSO system at various power levels:

Figure 4 represents the BER for different channels upto 4 km distance. For example, for channels 1, 2, and 4, the BER values are 1.55e-9, 9.64e-7 and 1.911e-5 for 10 Mw power at 1 km distance. For the same channels, the BER values are obtained: 1.05e-25, 1.32 e-18 and 3.2 e-15 for 40 Mw at 4 km.

Figure 5 shows Q-factor versus distance upto 4km. For channels 1, 2, and 4, the Q-values are 6, 5 and 5 for 10 Mw power at 1 km. For the same channels the Q-value are 10, 9, and 8 for 40 Mw power at 4 km in the designed system. So, it has been observed that signal power also effects quality of received signal. If power increases, the quality of the signal strength increases. So, the power level has an impact on the OCDMA-FSO system.

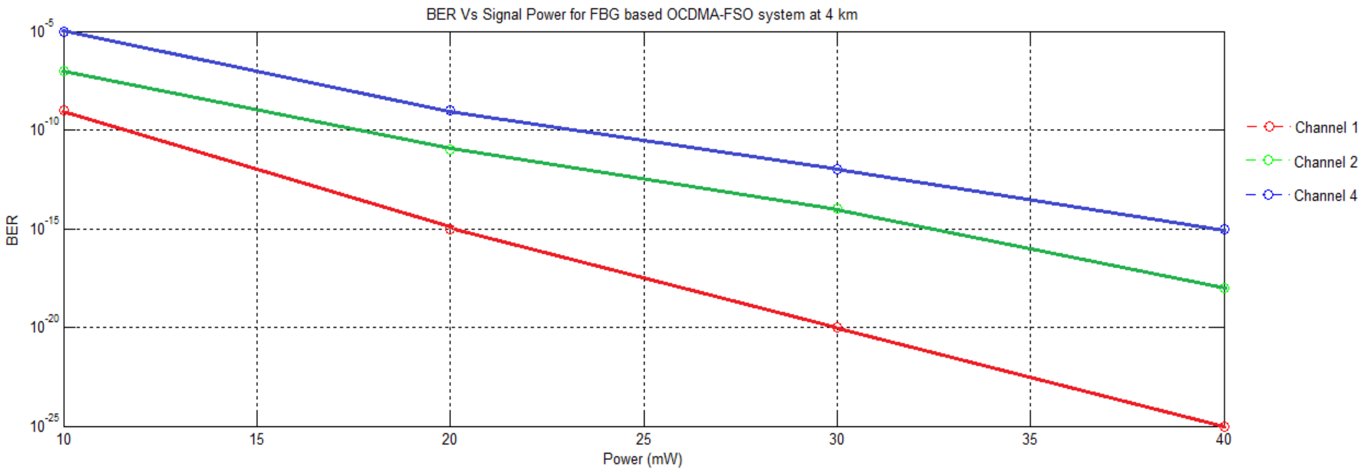


Fig4. BER Analysis of FBG based OCDMA-FSO system at different channels at various power levels

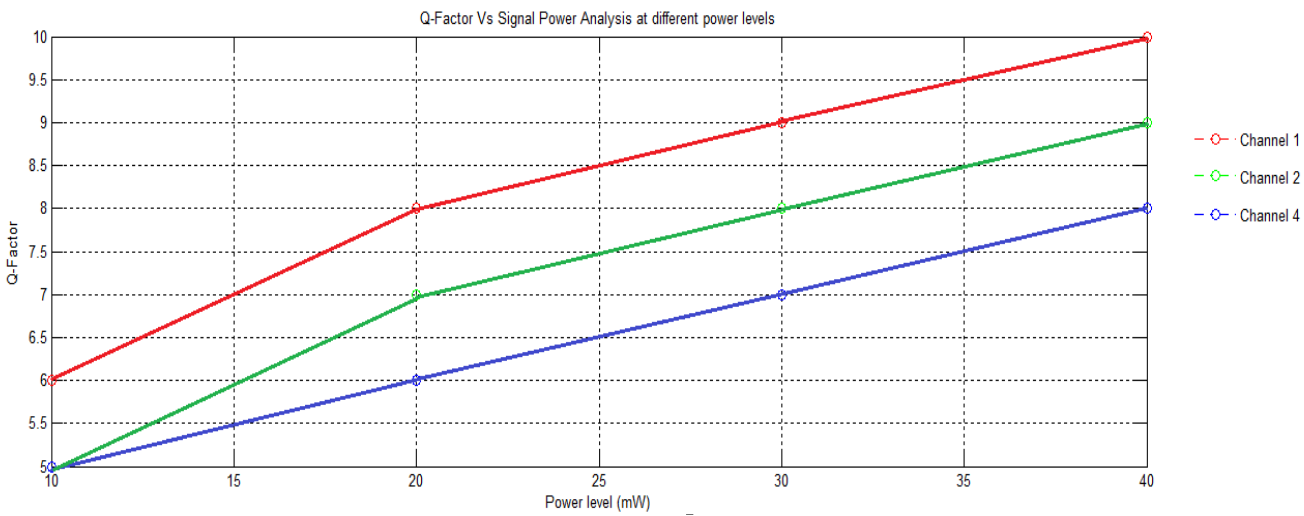


Fig5. Q-Factor Analysis of FBG based OCDMA-FSO system at different channels at various power levels

IV.CONCLUSION:

We successfully demonstrated a four user FBG encoder based OCDMA-FSO system operating at 5 Gb/s with a low-power requirement per user. The performance of the system is analyzed under various atmospheric conditions. It is concluded that system performance is best when clear weather attenuation (0.1 db/km) is considered, degrades inhaze condition (4db/km) and worst in fog weather(20db/km) condition. In clear weather attenuation, the system gives us excellent performance and offers extremely high quality of service and low bit error rate. The system is also analyzed at various distances for all the three atmospheric conditions.

The performance investigation of the FBG based OCDMA-FSO system at different number of channels for distance upto 4 km at various power levels was also carried out. It has also been observed that the signal strength and quality of service increases with the increase in transmitted power.

REFERENCES

[1] Kumar N., Singh T.,(2012), "2.50 Gbit/s optical CDMA over FSO communication system," Industrial Electronics (ISIE), IEEE syposium , pp957-962.

[2] Humble P.,(2011), "On the bit error rate of light wave systems with optical amplifiers," International Journal Institute Optical Communication, Vanderbilt University, USA.

[3] Kumar P, Sharma A, Kapoor V.,(2012), "Performance evaluation of free space optics communication system in the presence of forward error correction techniques," Industrial Electronics (ISIE), IEEE symposium, pp. 911-922.

[4] Kennedy P., Bakay R., Moore M., Adams K.,(2011), "Performance Evaluation of the Free space Optical communication with the effects of the atmospheric turbulences," International Journal Institute Optical Communication,Vanderbilt University,USA.

[5] Kumar B, Singh N.,(2011), "1.25Gbit/s optical CDMA over FSO comm. system," Industrial Electronics (ISIE),IEEEsyposium , pp911-934.

[6] Henninger H, Willert O., (2010), "An Introduction to Free-space Optical Communications", Radio Engineering , Vol. 19, No. 2.

[7] Sharma V., Kaur G., (2013), "High speed, long reach OFDM-FSO transmission link incorporating OSSB and OTSB schemes", Elsevier, IJLEO.

[8] Fadhila H., Amphawanb A., Shamsuddina H., Abda T., (2013), "Optimization of free space optics parameters", International Journal Institute Optical Communication, Vanderbilt University, USA, Elsevier Gmbh.

[9] Zhao L., Peng L.,(2011), "A MPR optimization algorithm for FSO communication system with star topology", International Journal of Optics Communications, pp147–154.

[10] Wang P., Lixin Guo B.,Shang T.,(2015), "SER performance analysis of MPPM FSO system with three decision thresholds over exponentiated wei bull fading channels", International Journal of Optics Communications173-185.

[11] Sharma V., Lumba M., Kaur G., (2014), "Severe climate sway in coherent CDMA-OSSB-FSO transmission system "., Elsevier, Volume 35 .

[12] Amphawanb A., Shamsuddina B., Hussein M., (2014), "Optimization of free space optics parameters: An optimum solution for bad weather conditions" Elsevier ,Volume33.

[13] Singh T., (2015), "Optical CDMA over FSO communication system", International Journal of Optics Communications, pp. 173-185.

[14] Wang J., Zhao G., and Gang W., (2015), "Free-space laser communication system with rapid acquisition based on astronomical telescopes", An optimum solution for bad weather conditions". Elsevier , Volume 33.

[15] Nakayama, K, Inagaki, K., (2015), "Applications of the FSO communication systems". International Journal of Optics Communications, pp. 173-185.

[16] Kumar N., Sharma A., Kapoor V., (2013), "Performance evaluation of free space optics communication system in the presence of forward error correction techniques," International Journal of Optics Communications, pp133-155.

[17] Majumder S., Azhari A., Abbou F.,(2015) "Impact of chromatic dispersion on the BER performance of an optical CDMA IM/DD transmission system," IEEE Photon.Technol.

[18] Parkash S., Sharma A.,(2016),"Performance Investigation of 40 GB/s DWDM over Free Space Optical Communication System Using RZ Modulation Format," Advances in Optical Technologies, Hindawi Publishing Corporation, Volume, 2016.