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Analysis Performance of FSO System Using RZ and NRZ Technique at Various Data Rate and Link Distance

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Abstract: Free Space Optical (FSO) communications has regained a great interest over the last few year, where optical transmission line uses the optical fibers cables as medium but in free space optical link we us the space as the medium to transmit the optical signal. The transmission medium of free space optical is significantly affected by the various weather conditions such as rain, fog, snow, wind, etc.

The performance of FSO system has faced adverse consequences due to various changes in the properties of the channel such as weather conditions and length of the channel up to which the information needs to be transmitted. This paper, study quality factor (Q-factor) for using two types of modulation formats and compares their performance. Hence the performance was analyzed by the Q-factor with respect to varying distance, data rate.

Keywords: Free Space RZ and NRZ technique, Q-factor, optical communications

I. INTRODUCTION

Free Space Optics (FSO) is a communication technology that uses light as carrier and free space as medium to transfer information between transmitter and receiver separated by certain distance as shown in fig. 1. FSO link is a wireless link between a transmitter and a receiver in optical communication system. The motivation for FSO is to eliminate the cost, time, benefit of high data rates (up to 1 GB/s and beyond) for transmission of data, voice, video and images. In addition, operating at unlicensed optical wavelengths, will provide broadband capacity and high security because of their directivity, their low cost and more compact equipment have emerged these systems as a complement to microwave and radio frequency (RF)counterparts[1].

FSO communication over 1–5 km distances has been demonstrated at 1–7 Gbps data rates. FSO technology facilitates broadband communication capacity using optical band. [2] The performance of FSO system is related to the transmission elements such as, modulation formats, type of Laser, transmission window, and atmospheric attenuation that is, signal degradation, signal absorption, scattering and scintillation [3].

In FSO system different modulation techniques are used to modulate information signal at source. Each FSO system uses a high-power optical transmitter for transmit source signal towards destination and receiving side high sensitivity receiver used. But the atmospheric attenuation is major challenge for faced by FSO systems which affect the performance of the link. The other factors which can affect the FSO are humidity, water vapor, signals absorption, smoke, beam scintillation, spreading and wandering.

FSO systems operate in the infrared (IR) range of spectrum, needs to line-of-sight between the transmitter and receiver for proper operation of an FSO system. FSO systems operates around 850 and 1550 nm wavelengths and the frequencies corresponding to this range of wavelengths is around 200 THz. 1550nm wavelength is preferred because of more eye safety and reduced solar background radiation. It has a capability to transmit the information signal with very high data rate ,with very high speed up to 2.5 Gbps through the free space with secure transmission of voice and image signals over distances up to several kilometers as compared to other technologies.[4]

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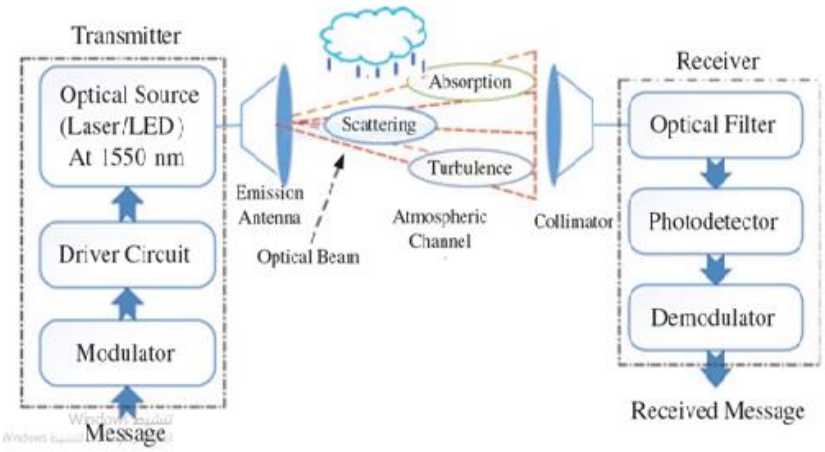

Figure 1. Block Diagram of Free Space Optical System

II. MODULATION TECHNIQUE RETURN-ZERO AND NON RETURN-ZERO

Return to zero (RZ) and non-return to zero (NRZ) are the popular techniques, which are used to encode optical pulses in optical link. In a simple comparison, the NRZ technique requires less bandwidth for transmission than the RZ and it is not sensitive to laser phase noise. Also, while the NRZ is more economical, the RZ, on the other hand, is more tolerant to nonlinearity than the NRZ [5]. The results showed that NRZ pulse shape was superior compared with RZ for duo binary transmission in all the cases that were studied including systems that are limited by amplified-spontaneous noise, fiber chromatic dispersion and self-phase modulation[6].

III. SYSTEM DESIGN MODEL

FSO design has modeled and simulated for performance characterization by using Optisystem 7.0. The FSO design model is illustrated in Fig. 1. FSO system's performance is studied based on different parameters (i.e. Data rate, range, Link distance). In our proposed design, the optical transmitter consists of three subsystems. The first subsystem is the Pseudo Random Binary Sequence (PRBS) generator. This subsystem is to represent the information or data that wants to be transmitted. The output from a PRBS generator is a bit stream of binary pulses; a sequence of "1"s (ON) or "0"s (OFF). The second subsystem is the tow different modulation format (RZ,NRZ) electrical pulse generator. This subsystem encodes the data from the PRBS generator by using the different modulation format Return Zero and Non Return Zero technique. The third subsystem in the optical transmitter is the direct modulated lasers. Direct modulated lasers based on InGaAs semiconductor technology with operating wavelengths around 1550 nm [7]. The FSO system performance is analyzed using BER analyzer. It gives us Q factor, eye diagram analysis

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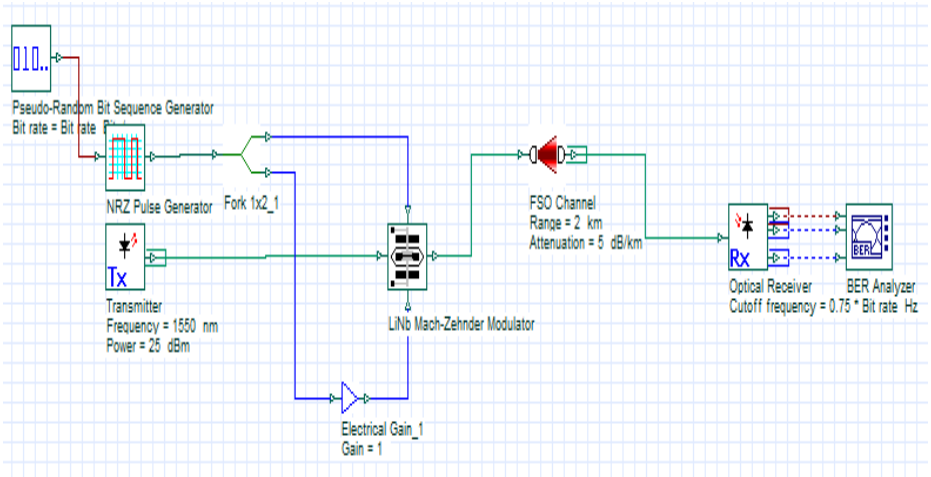

Figure 2. Single channel FSO system using RZ format

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IV. RESULTS AND DISCUSSIONS

1- THE EFFECT OF DISTANCE LINK

In our simulation we have varied the length of the channel whose length is 2-10Km at different modulation format by taking values of the various parameters like: Data rate 2Gbps, transmitter Wavelength 1550 nm, aperture area 180 cm2, transmitted power 25 dBm, Divergence angle 3 mrad, Geometrical loss 2 dB, Fig. 3 shows the Q value versus transmission distance having some parameter of RZ and NRZ modulation. From Figure (4) it has been observed that there is significant decrease in Q value which lies within (22,3) to (16,3) for transmission distance of 2km and 10 km in case of RZ and NRZ technique respectively.

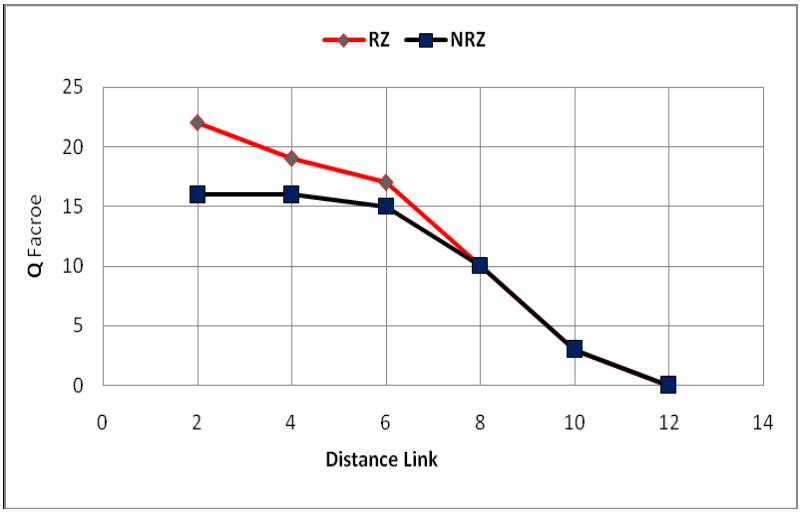
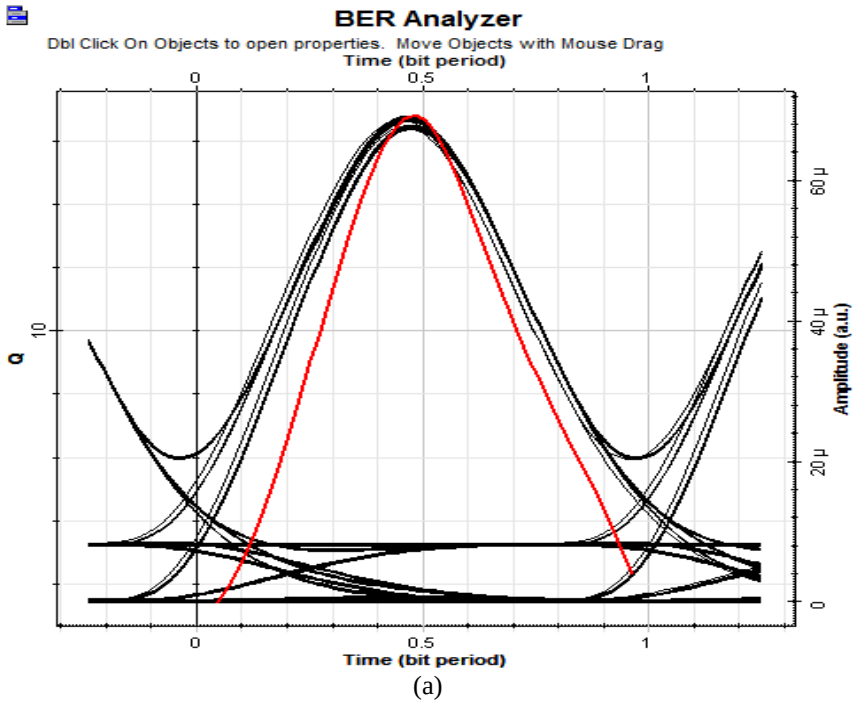


Fig 3. Q-factor vs. Distance link using different modulation technique,.

From above discussion it is clear that RZ modulation give better performance compared to NRZ modulation up to 8 km and after that RZ and NRZ have almost the same, for small ranges RZ performs well.



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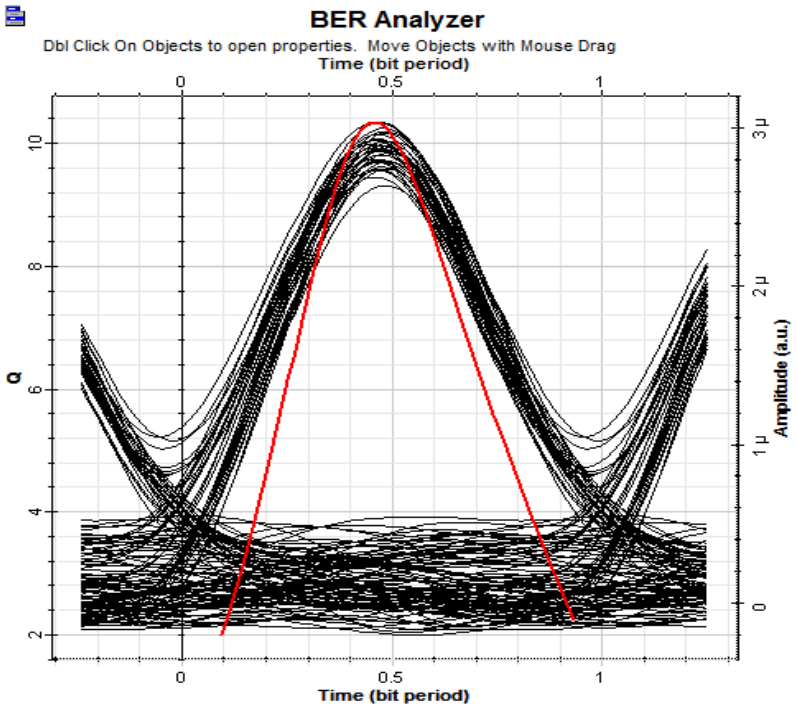
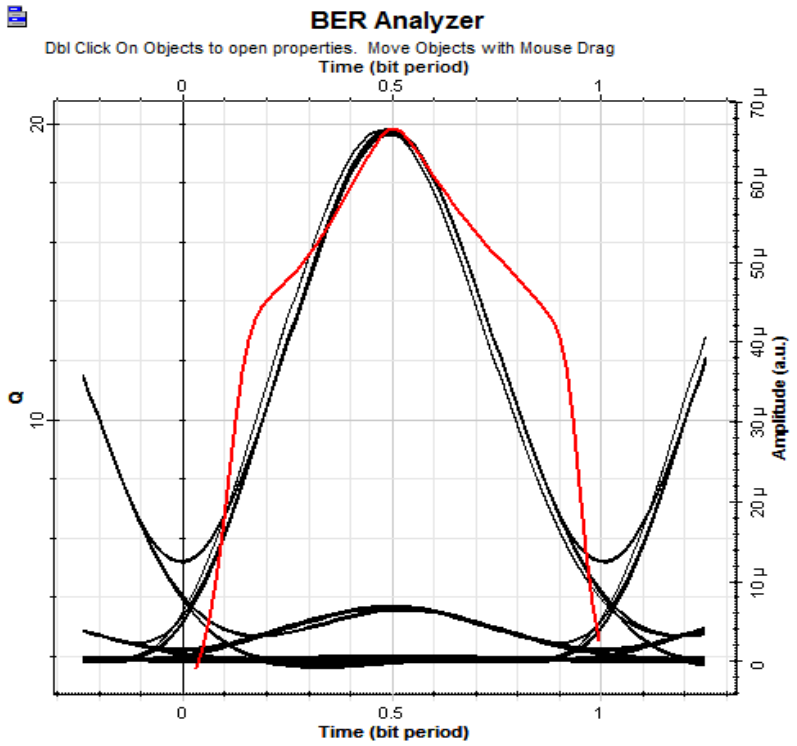


(b)

Fig 4. Eye diagram for (a) 4 Km link distance, (b) 6 km link distance free space optics link using RZ format

Fig 4, 5 shows the eye diagrams of NRZ and RZ at different transmission distances. The RZ and give good eye opening even at lower transmission distances but can very narrow eye diagrams for FSO channel because increasing noise and interference by increase distances.



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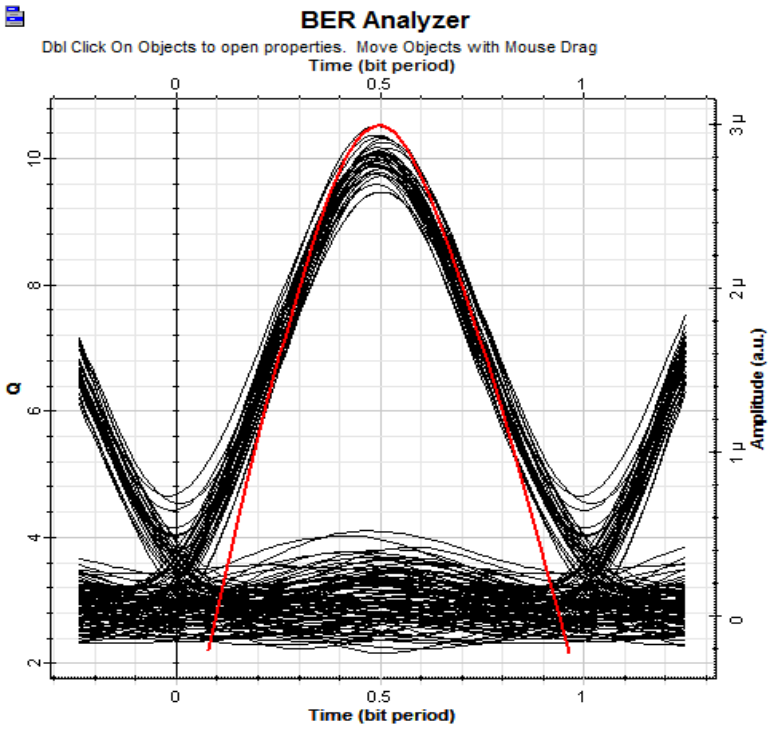

(b)

Fig 5. Eye diagram for (a) 4 Km link distance, (b) 6 km link distance free space optics link using NRZ format

2- The Effect of Data Rate

Data rate is altered to observe its effect on system performance and Q-factor. Data rate values range from 1Gbps up to 10Gbps, The link parameters with their symbols and corresponding values are presented in table-1.

TABLE 1. SIMULATIONS PARAMETERS

Parameter	Values
Frequency	1550 µm
Frequency spacing	100 GHz
Power	500mw
Extinction ratio	10
Link Distance	10-30Km
Attenuation	0.1dB/km
Data Ra	100-500 Gbps
Transmitter aperture diameter	10 cm
Receiver aperture diameter	15cm
Beam divergence	0.25mrd

We can observe from Fig.7 that Q-factor is more than 500 in NRZ modulation format whereas Q-factor is 250 in RZ. From the comparison of Eye Diagram, BER and Q-factor we can observe that performance of free space optics point to point of length 2 km using NRZ is better than free space optics channel of 2 km using RZ modulation format. In data rate ranging from 1 to 12 Gbps, NRZ remains at top compared with RZ with highest Q factor.

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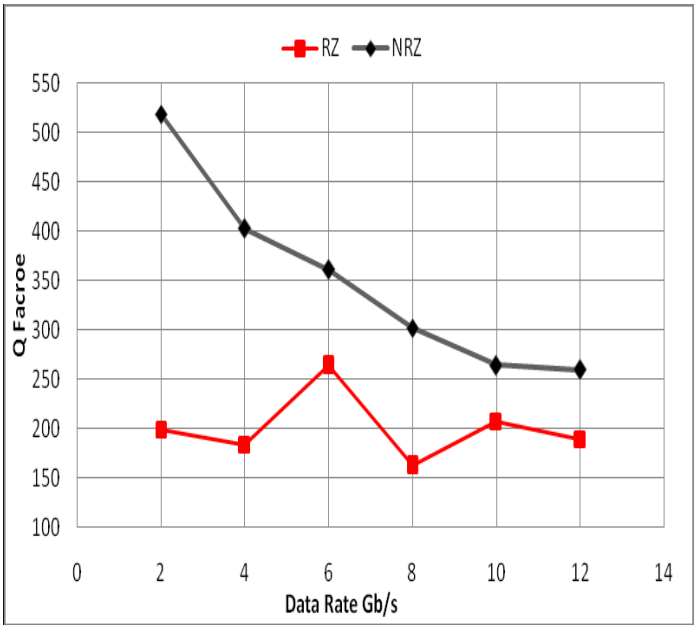

Figure 7. Q-factor vs. Data Rate using different modulation technique,.

V. CONCLUSION

This work presents the impact of NRZ and RZ modulation technique, which shows the effect of distance and data rate in Q-factor. the Q factor was higher using RZ system compared to the NRZ at different ranges of distance. For short link ranges, RZ seems to be a good candidate. and NRZ systems have shown to have better performance compared to the RZ systems with higher Q-factors and for different data rate value.

REFERENCES

[1]. Shehab A. Kadhim, Alaa H. Ali Kanat M. Abdul Hussain. "Simulation and Comparative Analysis of SISO over MIMO FSO Communication Channel" *IJIRSET Vol. 6, Issue 4, April 2017*

[2]. Dheeraj duvey, Er. Ritu gupta. "Review paper on performance analysis of a free space" *IJAIEM Volume 3, Issue 6, June 2014.*

[3]. Ali Mehdi Hammadi1, Ali J. Al-Askery, Entidhar Mhawes Zghair "Quality Factor and SNR Compensation of Free Space Optical Communication Link Using Different Modulators". *IJET, 7 (4), 3747-3751, 2018.*

[4]. H.Singh, M.Arora, "Investigating Wavelength Dependency of Terrestrial Free Space optical Communication Link", *IJSRST, vol. 2, ISSN: 2395-6011, May 2016.*

[5]. Chris Xu, Xiang Liu, Linn F. Mollenauer, Xing Wei, "Comparison of Return-to-zero Differential Phase-shift keying and on-off keying in Long-haul Dispersion Managed Transmission", *IEEE Photon. Technol. Lett., Vol. 15, No. 4, pp. 617-619, 2003.*

[6]. Cheng-Chung Chien, Ilya Lyubomirsky, "Comparison of RZ versus NRZ Pulse Shapes for Optical Duobinary Transmission", *J. Light wave Technol., Vol. 25, pp. 2953-2958, 2007.*

[7]. Jitendra Singh, Naresh Kumar "Performance Analysis of Different Modulation Format on Free Space Optical Communication System" *Optik 124,4651– 4654, 2013.*