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Study and performance evaluation of Radio over Fiber using Mach Zehnder Modulator

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Abstract: Radio over Fiber (RoF) is attractive technology used for wireless broadband Internet access in which radio signals are modulated on to light and transmitted over optical fiber cable. At the receiving end the optical signal is converted to an electrical signal, amplified and transmitted to the base station. In this paper we have designed a two RF channel optical link over using MZM modulator and the performance of designed link is analyzed at variable optical fiber length based upon variations in BER, Q factor and Eye Diagram analyzer using the Optisystem.

***Keywords*:** RoF, Radio Frequency (RF), Control Station (CS), Base Station (BS), Central Office (CO), MZM.

I. INTRODUCTION

Optical Fiber communication technology is rising exponentially in the present era and has enabled long distance communications with lesser losses in transmission medium. Optical Fiber is capable of accommodating larger amount of data rates as compare to any other transmission medium [1][2]. The design complexities in these systems are increasing continuously and to meet these increasing consumer needs effectively and efficiently, optical fiber communication is the most preferred way to increase the transmission capacities of communication systems.

II. RoF

In RoF a light signal is modulated by a radio signal followed by transmission through optical fiber in order to support wireless applications.

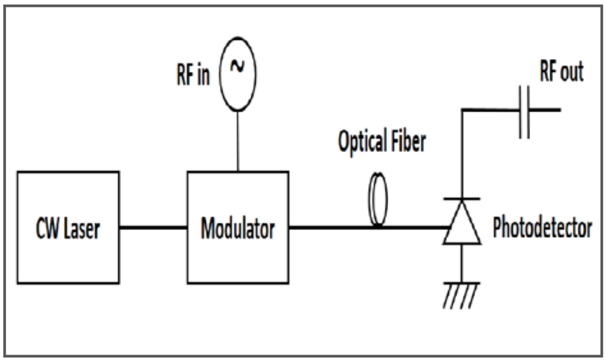


Fig. 1 Basic block diagram of RoF System

Figure 1 shows the basic block diagram of a RoF system. In this a CW laser carrier is modulated using a modulator (MZM) according to an input RF [11]. It is an analog transmission system because it involves sharing of radio signals, directly on radio carrier frequency which are transmitted between control unit and BS. At transmitter, the optical laser source is modulated by an electrical signal. This modulated signal is in optical domain which is further transmitted through the optical fiber. At receiver, photo detector converts back the information signal into electrical form. [3].

III. OPTICAL MODULATION

In optical communications systems, data of communications traffic is transmitted by optical carriers. The optical carriers can be Amplitude Modulated (AM) or Phase Modulated. The process of Modulation is the most important technique in RoF system where the RF electrical signal is applied to modulate the optical carrier signals [4]. These modulation methods can be categorized into two main groups:

A. Direct Modulation: In direct modulation techniques known as intensity modulation (IM), the amplitude of the laser beam directly modulated according to input RF Signal as shown in Figure 2. Limited bandwidth, pulse spreading and information losses are limitations of direct modulation.

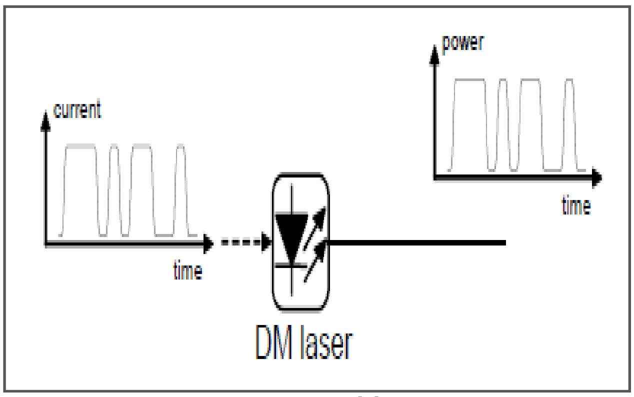


Fig. 2 Direct Modulation

B. External Modulation: An un-modulated laser source is required in external modulator as shown in figure 3. Electro Absorption modulator (EAM) and MZM each having different principle of operation are the commonly used external modulators. In this we used MZM for the performance analysis of RoF system.

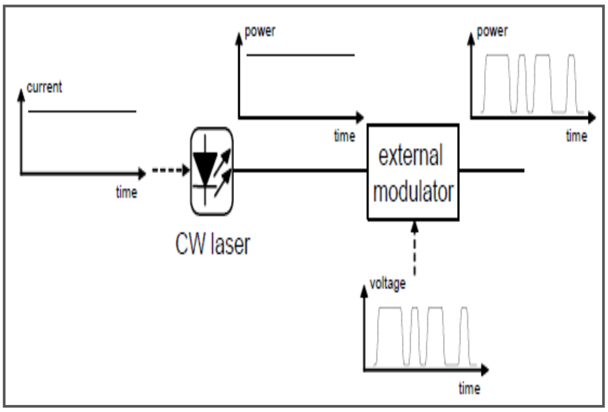


Fig. 3 External Modulation

As direct modulation is ideal for inexpensive transmitters, but it causes excessive chromatic dispersions and undesirable wavelength chirp, which results excessive chromatic dispersion at high speeds hence External modulation is preferred.

MZM is a preferred modulator generally termed as an electrical to optical (EO converter). Recent researches in the field of MZM reveal that, MZM can be used more than just an EO converter like to achieve linearization or for the compensation of dispersion introduced in the signal while travelling through an optical path. Specially designed MZM can resolve both the issues simultaneously [5].

IV. WORKING PRINCIPLE OF MZM

The most popular modulator in optical communication systems is the Lithium Niobate (LiNbO3) MZM. It is of two types single drive MZM and dual-drive MZM. The block diagram of MZM is shown in Figure 4. The optical wave enters from the input side and then splits equally into its two arms.

The structure of the dual-drive MZM has two arms and electrodes [6].

MZM is used to control the phase and amplitude of an optical signal. The input waveguide splits into two waveguide arms and bias is applied to these arms which induces a phase shift during the passage of wave through these arms. The optical signal travelling through both arms of the interferometer are recombined at the output of MZM and the phase difference between the two waves is converted into the Amplitude Modulated wave [12].

Phase shifted RF signals are applied to the two arms of the interferometer biased with different DC voltages. By changing the applied voltage on the electrode, the optical phase in each arm can be controlled. Advantages of MZM- Flexibility in fringe location can be provided by the Mach-Zehnder Modulator, but it is not possible with other interferometers. In Mach-Zehnder interferometers rectangular arrangement is commonly used [7].

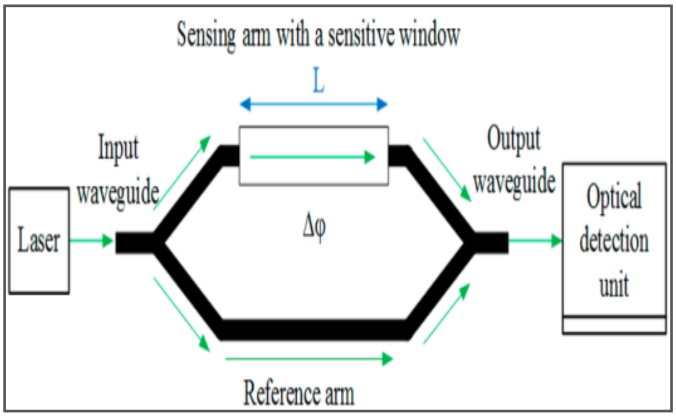


Fig. 4 Block diagram of Mach Zehnder modulator

V. PROPOSED BLOCK DIAGRAM

We have designed a RoF system in which two RF channels are combined and modulated using MZM modulator. Figure 5 shows the block diagram of proposed layout.

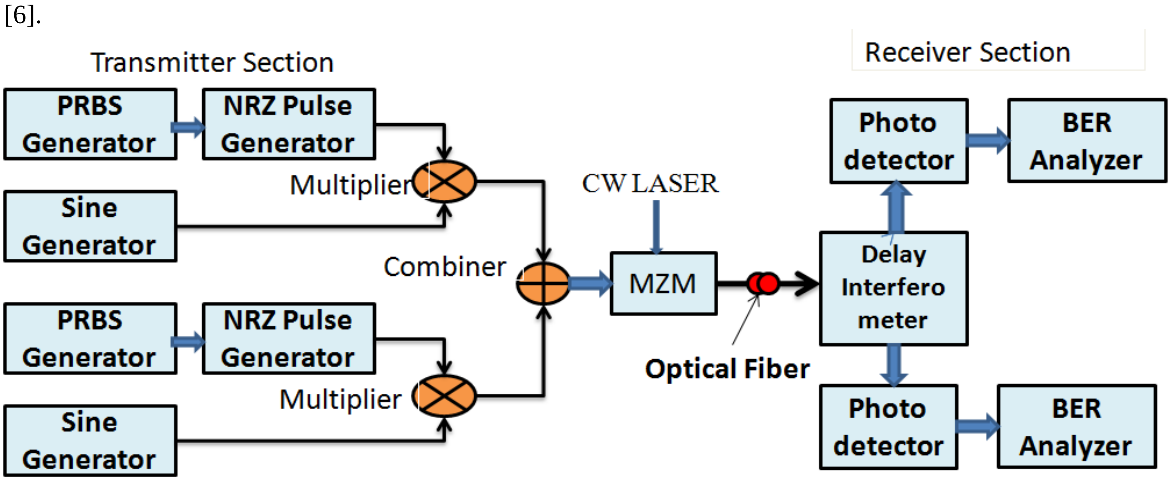


Fig. 5 Block diagram of proposed system

VI. SIMULATION SETUP

We have designed two RF channels optical link based on RoF system using OPTISYSTEM. We have analyzed the performance of the system at various distances 10, 20, 30, 40 and 50kms.

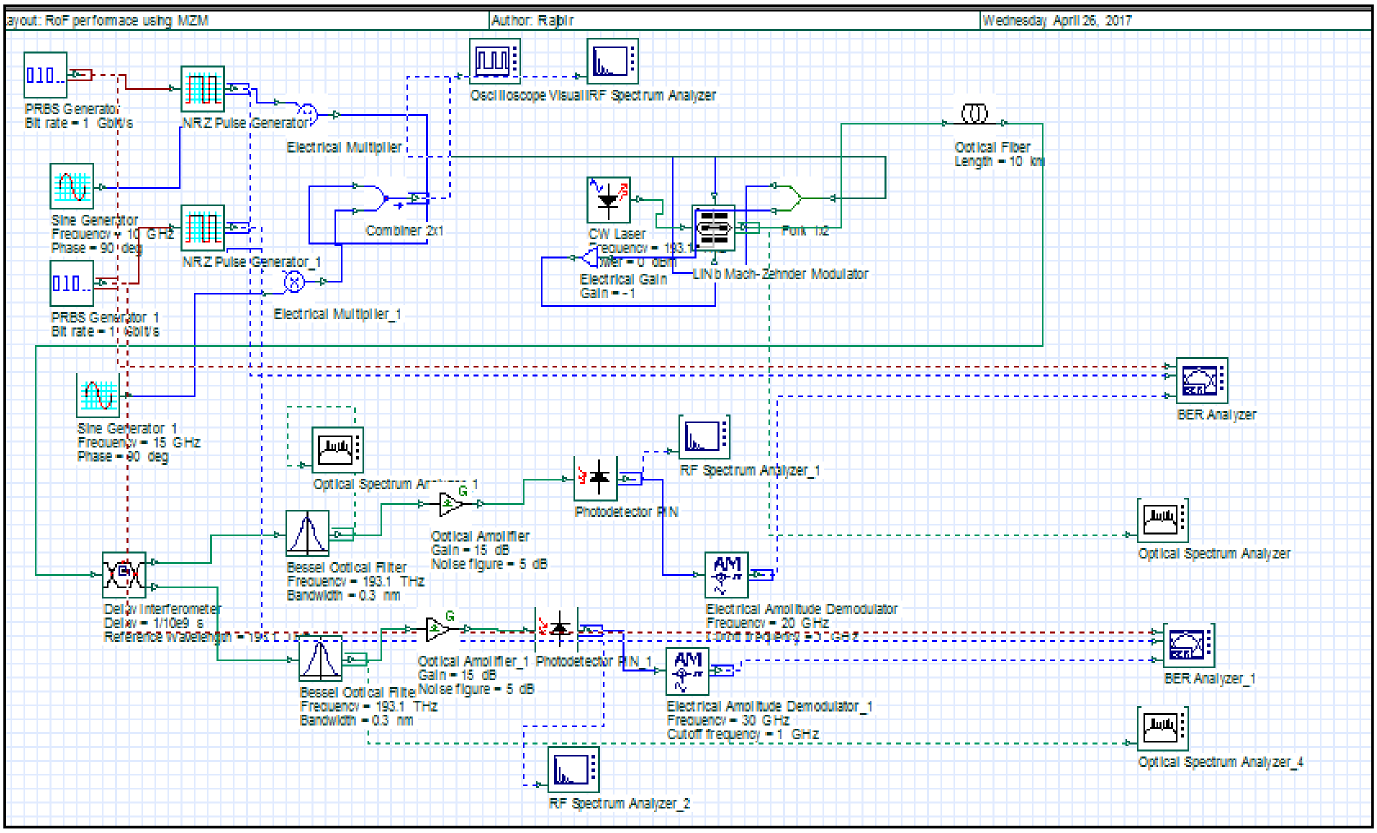


Fig. 6 Radio over Fiber link simulation setup using MZM

VII. SIMULATION PARAMETERS

The analysis of designed optical link was performed using OPTISYSTEM simulator based upon several qualitative Parameters such as Q-Factor and BER. The parameters used in simulations are shown in the table 1 given below:

Table I: Parameter values of Simulation Setup

Parameters	Values (units)
PRBS Generator Bit Rate	1 Gbit/s
Fiber Length	10, 20, 30, 40,50km
Modulation Format	NRZ,
MZM Extinction Ratio	30dB
MZM Insertion Loss	2dB
Optical Fiber Attenuation	2dBm
Electrical Amplitude Demodulator Frequency	20GHz

VIII. RESULT AND DISCUSSION

We have performed the simulation using OPTISYSTEM based upon qualitative parameters such as Q-factor and BER.
Q-Factor: Q-factor is a function of signal to noise ratio. It gives the the performance of receiver qualitatively. The Q-factor define the minimum signal to noise ratio require to acquire a specific BER for a given signal.

BER: In digital transmission the number of data bit received has been altered due to distortion, noise, interference, in bit or synchronization errors [10]. The bit error rate (BER) is the ratio of number of bit errors to the total number of transferred bits

Table: II Variation of BER and Q-factor with distance

Sr. No.	Distance	Channel 1		Channel 2	
		Max. Q Factor	BER	Max. Q Factor	BER
1.	10 km	21.2355	1.92559e-100	18.075	2.32884e-73
2.	20km	16.771	1.96325e-63	15.7883	1.76688e-65
3.	30km	16.3341	1.81547e-60	15.9469	1.48938e-57
4.	40km	15.6513	1.62535e-55	13.6047	1.688e-42
5.	50km	15.4905	1.97366e-54	11.1546	3.11996e-5

during a studied time interval [8]The results obtained are given in the Table II. From the table II, it is evident that the designed optical link performs satisfactorily as Q-Factor for both channel 1 and channel 2 decreases with increase in fiber length, whereas the value of BER increases with increase in distance
The values of Q-factor for channel 1 are 21.2355, 16.771, 16.3341, 15.6513 and 15.4905 for 10, 20, 30, 40 and 50 kms respectively and it is for channel 2 are 18.075, 15.07883, 15.9469, 13.6047 and 11.1546 at distances10, 20, 30, 40, and 50kms respectively.

Figure 7 shows the variation of Q-factor with increasing optical fiber length for channel 1 and channel 2. Q-factor decreases as the length of optical fiber increases.

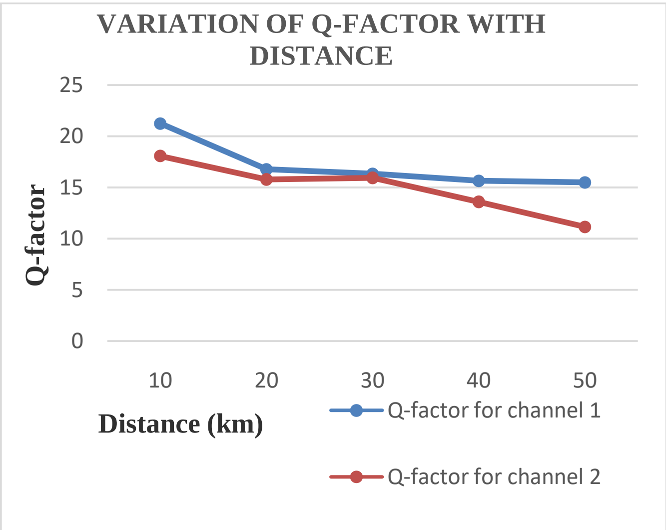
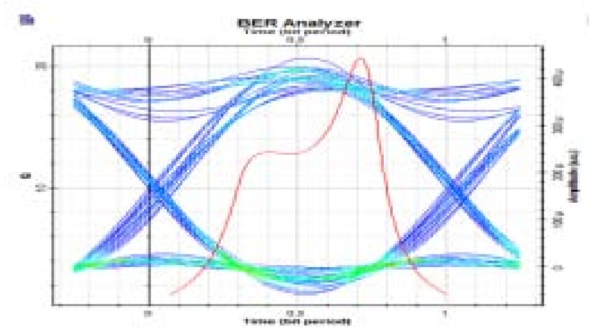


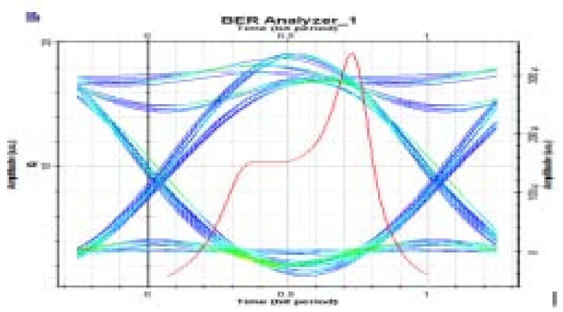
Fig. 7 Variation of Q-factor with Fiber length

Eye Diagrams Analyzer: The Analyzer of OPTISYSTEM shows multiple paths of a modulated signal to produce an Eye diagram. The performance of the system was also analyzed using BER analyzer. The Eye pattern with MZM

modulation gives a larger eye opening [9]. The figure 8 given below shows the Eye diagram at various distances.

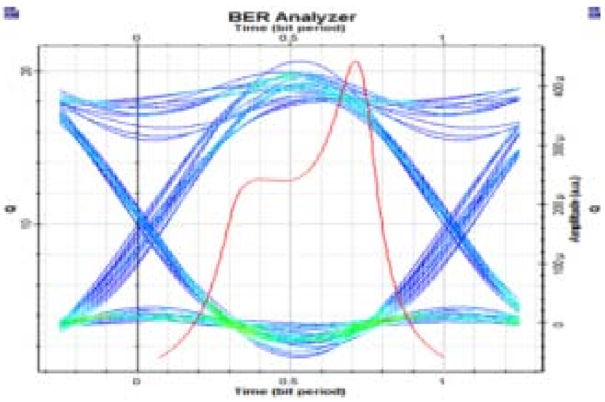


(a)

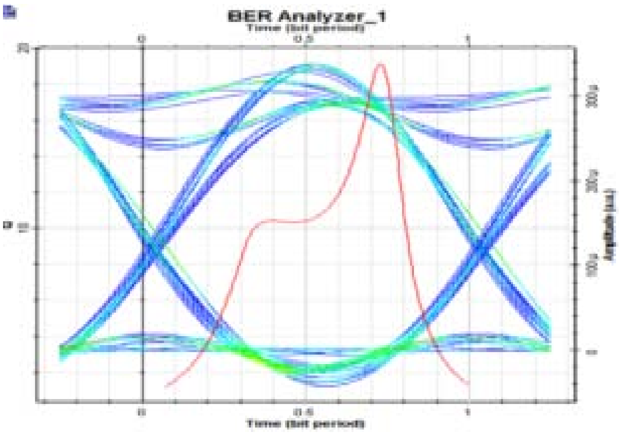


(b)

Fig. 8 (a) &(b) Eye Diagram analyzer for channel 1 and channel 2 at 10 km

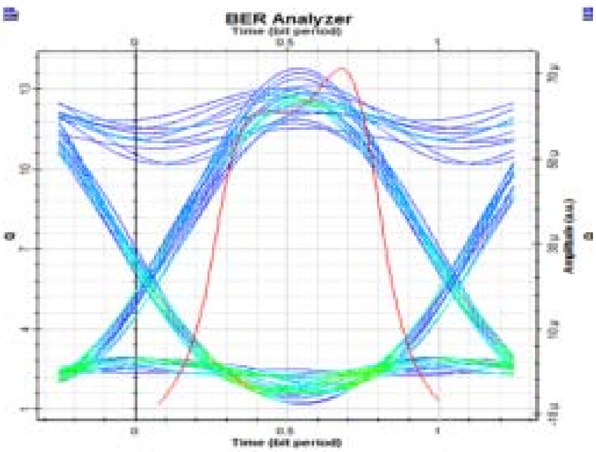


(c)

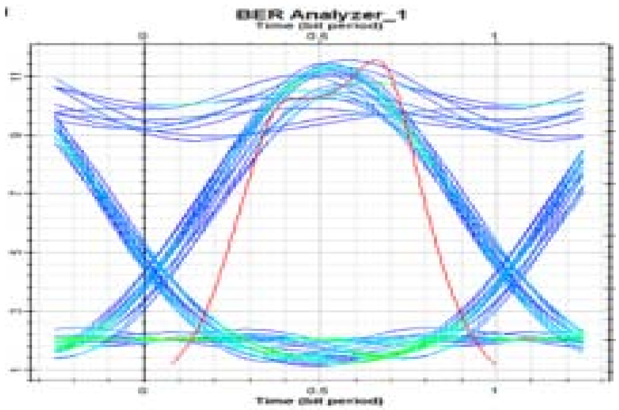


(d)

Fig. 8 (c) & (d) Eye Diagram analyzer for channel 1 and channel 2 at 20 km

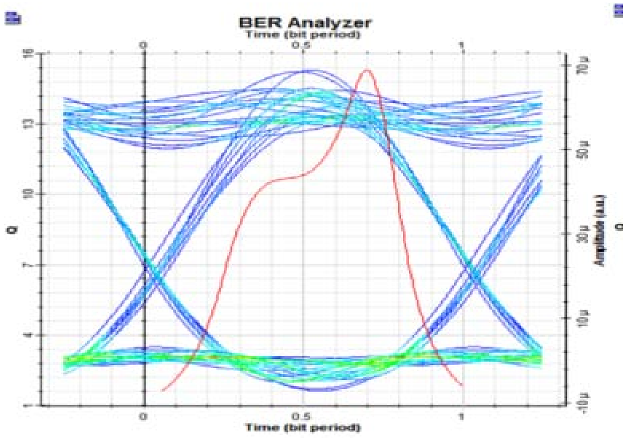


(e)

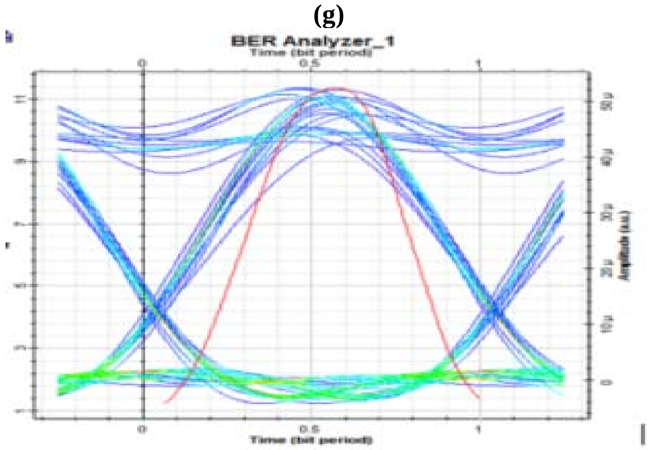


(f)

Fig. 8 (e) & (f) Eye Diagram analyzer for channel 1 and channel 2 at 30 km

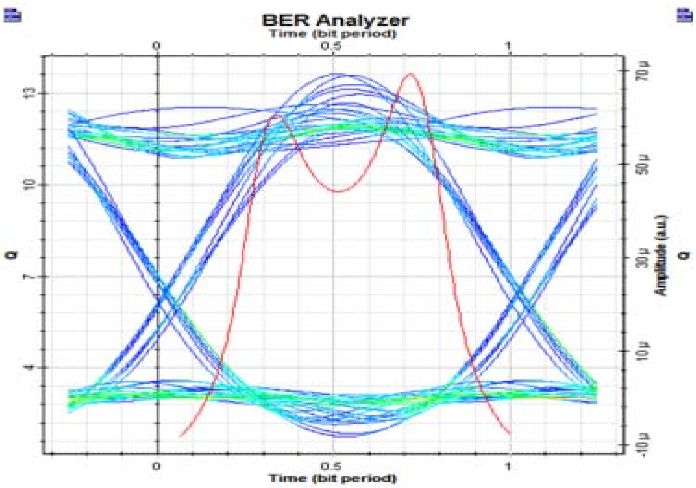


(g)

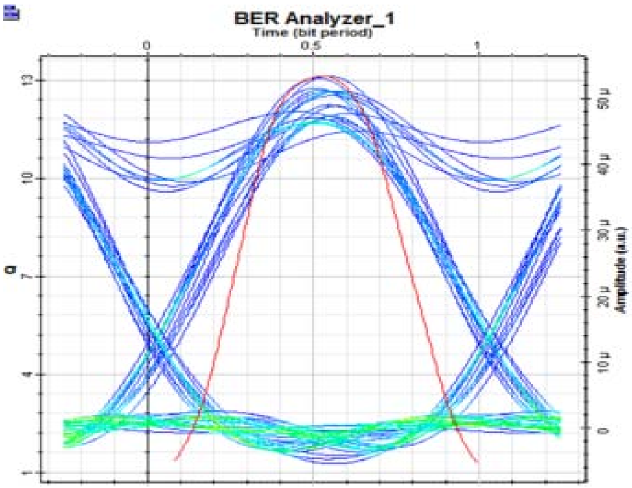


(h)

Fig. 8 (g) &(h) Eye Diagram analyzer for channel 1 and channel 2 at 40 km



(i)



(j)

Fig. 8 (i) &(j) Eye Diagram analyzer for channel 1 and channel 2 at 50 km

From Figure 8, the eye diagrams obtained at BER analyzer are shown. These eye diagrams have a larger eye opening, greater eye height and width and there is less distortion among the various spectral components. .

IX. CONCLUSION

In this proposed work we have successfully designed a RoF system link using MZM modulator and simulated using Optisystem for parameters such as BER, Q-factor, for different fiber lengths. The values of Q-factor for channel 1 are 21.2355, 16.771, 16.3341, 15.6513 and 15.4905 at distances10, 20, 30, 40 and 50 kms respectively. The values of Q-factor for channel 2 are 18.075, 15.07883, 15.9469, 13.6047 and 11.1546 for 10, 20, 30, 40, and 50kms respectively. The values of BER are in the range of 10^{-100} to 10^{-54} for channel 1 and it is in the range of 10^{-73} to 10^{-5} for channel 2. From all the observations and findings it can be concluded that for the proposed RoF system the Q-factor decreases and BER increases with increase in optical fiber lengths.

X. REFERENCES

[1] https://en.wikipedia.org/wiki/Radio_over_fiber

[2] Kamaljit Singh Bhatiaa, Sandeep Singh "Performance Analysis of RoF link using Mach-Zehnder Modulator and its parameters," An International Journal of Engineering Sciences, Special Issue ICTMS-15, 29-30 December 2015 ISSN: 2229-6913 (Print), ISSN: 2320-0332

[3] Fan Wei, Hanyi Zhang, and Bingkun Zhou Tsinghua, "Carrier Phase and Amplitude Manipulation for Linearization and Dispersion compensation in Radio-over-Fiber Systems Using Mach-Zehnder Modulator - Progress In Electromagnetic Research Symposium Abstracts,"Electromagnetics Research Symposium Proceedings, Stockholm, Sweden, Aug. 12-15, 2013 1311.

[4] Pradeep R and Vijayakumar N, "Performance Analysis of RoF link using Mach-Zehnder Modulator in radio over fiber systems, " International Journal of Advanced Research in Engineering and Technology (IJARET).ISSN Print: 0976-6480 and ISSN Online: 0976-6499Volume 7, Issue 5, September-October 2016, pp. 45–52, Article ID: IJARET_07_05_006 ISSN Print: 0976-6480 and ISSN Online: 0976-6499© IAEME Publication.

[5] Jincy John and Sreenesh Shashidharan,"Design and Simulation of a Radio over Fiber System and its Performance Analysis." Optical Networking Technologies and Data Security - OPNTDS 2012IEEE.

[6] Kamal Moussati, and Jamal Zaidouni Ghoumid, Slimane Mekaoui, Ali El,"16-QAM Modulation Based on Quad-Parallel Mach-Zehnder Modulator Dedicated for Radio-over-Fiber System," International Journal of Information and Electronics Engineering, Vol. 3, No. 5, September 2013

[7] M. Zhu, L. Zhang, J. Wang, L. Cheng, C. Liu, and C. Gee-Kung, "Radio-Over-Fiber access architecture for integrated broadband wireless services," J. Lightwave Technol. 31, 3614–3620 (2013).

[8] Balinder Singh and Davender Singh, "A Review on Advantages and Applications of Radio over Fiber System," International Journal of Current Engineering and Technology E-ISSN 2277 – 4106, P-ISSN 2347 – 5161.

[9] A.Bahrami, Student member, IEEE,T. Kanesan, W. P. Ng, Senior member, IEEE, Z. Ghassemlooy, Senior member, IEEE, A. Abd El Aziz, Student member, IEEE, S. Rajabhandari, Member, IEEE Optical, "Performance Evaluation of Radio-over-Fibre Systems Using Mach-ZehnderModulator"Researchgate.net/publication/231181708

[10] Bhumika A. Patel, Prof. Ankit Patel , "Performance Analysis of Optical Link using EDFA, " IJSRD - International Journal for Scientific Research & Development| Vol. 3, Issue 03, 2015 | ISSN (online): 2321-0613.

[11] Rajiv Chechi and Mukhwinder Kaur, "Radio over Fiber (RoF): A New Approach to High Speed Access Network", International Journal of Advanced Research in Computer Science(IJARCS). Volume 3, No. 6,Nov 2012 (Special Issue) ISSN No. 0976-5697.

[12] Rajbir Singh, Manoj Ahlawat and Deepak Sharma "A Review on Radio over Fiber Communication System", International Journal of All Research Education and Scientific Methods (**IJARESM**) ISSN: 2455-6211, Volume 5, Issue 4, April 2017.