Design and Simulation of RoF and FSO based Hybrid Network

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***Abstract*—** Free space optics (FSO) is an optics communication technology which utilizes light for the transmission of data through the air in same manner as the fiber optics. Radio Over fiber (RoF) is a technique in which signals are transmitted in the form of light and media use for the transmission is fiber optical cable. In this paper RoF and FSO based hybrid network is proposed and performance of developed networks investigated on the ground of distance, bit rate, input power etc. It is revealed that quality transmission with data rate of 3 Gbps is supported at fiber length of 27 km and free space distance of approx 800 meters.

Keywords*—Free space optics (FSO), Radio over Fiber (RoF)*

I. INTRODUCTION

Free space optics (FSO) is a wireless technology which use free space transmission medium to transmit data signal with high data rates. FSO research was started in 1960s [1]. It works on the principal of laser driven technology in which light source and detector are used to transmit and receive the information via the atmosphere same as fiber optics communication link. FSO is line of sight technology in which data, voice and video communication is attained with maximum data rates up to 10 Gbps using full duplex (bidirectional) connectivity [2]. FSO has various advantage like high data rate i.e. 10 Gbps, requires no licensing, Narrow beam angle, easy to deploy, back-haul for cellular communication, inexpensive and consume less power [3] . There are some drawbacks in the system like atmospheric turbulence and PAT (Pointing Acquisition and Tracking) technology, weather attenuation loss etc. [4].

Radio over Fiber (RoF) is a technology which is used to control the traffic over the network over the wireless communication network system. It is combination of two technique i.e. wireless and fiber optics network. It is a process in which light is modulated by radio frequency (RF) signal and RF signal is transmitted with the help of optical fiber. The frequency of the radio signal usually in GHz and based on the nature of applications [5]. It is full duplex communication is done by using WDM (Wavelength division multiplexing) and optical Add Drop Multiplexer. It accommodates the large no. of user as compared to traditional wireless communication system as it utilized large bandwidth of optical fiber and signal can be transmitted in outdoor range as well as in densely populated area of system are used to increase the cellular coverage inside building [6]. Radio over fiber (RoF) technology is find is many important applications i.e. broadband wireless access network, sensor network, radar and defense system etc [7]. RoF has various advantages like large Bandwidth, low attenuation, low complexity, lower cost and immunity to Radio frequency interference etc [8].

II. SIMULATION SETUP

An RoF and FSO based hybrid network is developed to study the performance of link against distance, input power, Bit Error Rate, Q value etc. The simulation study is carried out using optical simulator (OPTSIM). The Performance of the developed hybrid network analyzed in terms of BER, Eye Diagram value etc. The optical transmitter consists of a data generator and NRZ modulator and a directly modulated laser at wavelength 1550nm. Optical power of transmitter is 1.349m. The optical receiver is a PIN diode and out performance will be analyzed in terms of BER, Eye Diagram value etc. Bit rate is varied from 1.25 to 8.25 Gbps and distance is swept across the range of 15 to 30 km of fiber and 500m to 1300m of FSO link. Further simulation parameters are presented in table 1.

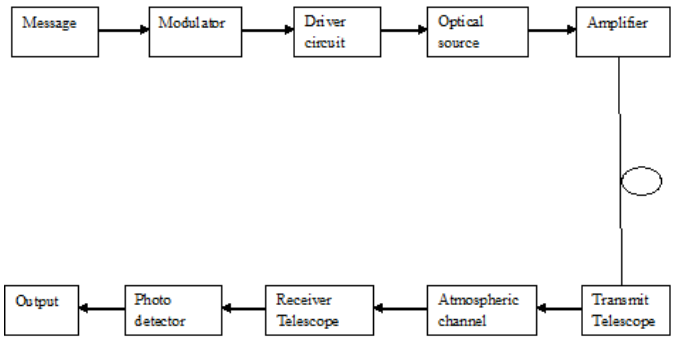


Fig 1:Block Diagram of devloped Hybrid Network

Table 1:Simulation Parameters.

Simulation Parameters	Values
Bit Rate	1.25 to 8.25
Fiber Distance	15 to 30 km
FSO Distance	500 to 1300m
Attenuation	-8 to -2 dBm
Beam Divergence	0.1718 rad
Small Siganl gian of amplifier	30 dB

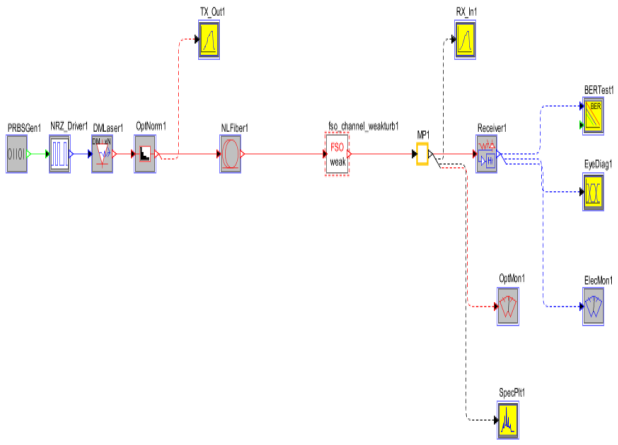


Fig 2: Develpoed/Designed Hybrid Network

III. RESULTS AND DISCUSSION

The designed network shown in figure 1 and 2 had been simulated on optical simulator (Optsim) under various parameters presented in table 1.

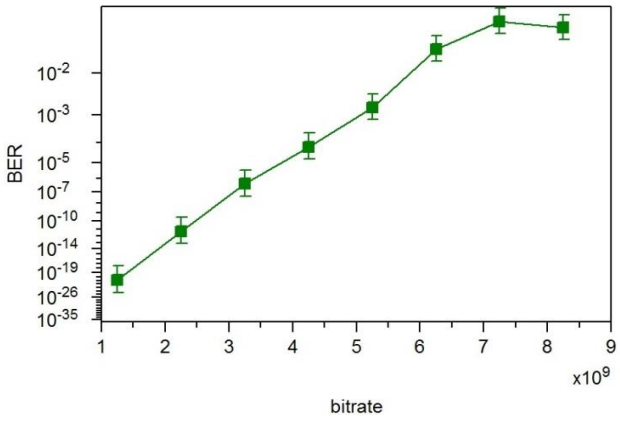


Fig 3: BER vs. Bit rate

Figure 3 shows the variations of BER with respect to bit rate. It has been observed that as bit rate increase from 1.25Gbps to 8.25Gbps. BER increases from 10^{-23} to 10^{-1} and the network provides good quality under 3 Gbps data rate.

Figure 4 shows the variations of BER with respect to FSO distance. It has been observed that as FSO distance is varied from 500m to 1300m. BER increases from 10^{-38} to 10^{-1}. Quality signal is detected when FSO distance is kept under approximately 800 meters.

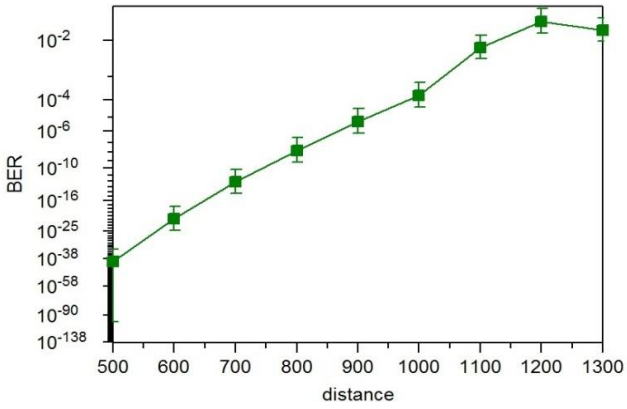


Fig 4: BER vs. FSO Distance

Figure 5 shows the variation of BER with respect to fiber distance. It has been observed that as fiber distance varied from 15 to 30 km. BER Also increase from 10^{-20} to 10^{-7}. Quality transmission is obtained when fiber distance is limited to 27 km approximately.

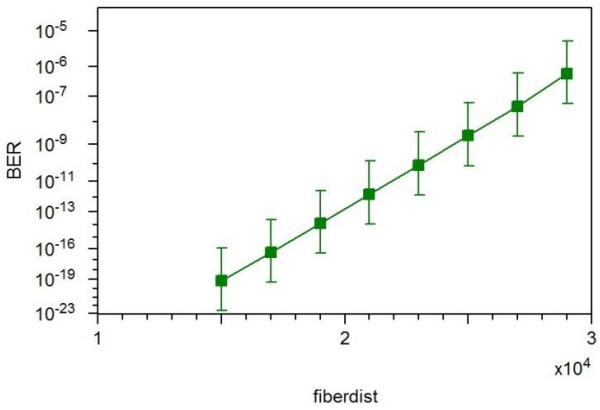


Fig 5: BER vs. Fiber Distance

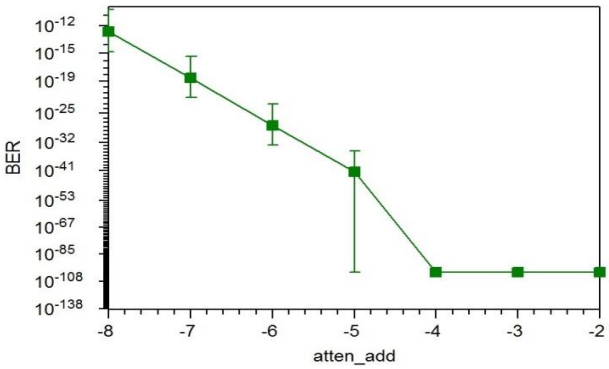


Fig 6: BER vs. Additional Attenuation

Figure 6 shows the variation of BER with respect to additional attenuation. It has been seen that as additional attenuation increase from -8db to -2db. BER Also decrease from 10^{-12} to $10^{-18}$and quality signal is detected when an attenuation is kept under -4db.

Figure 7 shows that variation of average electrical power with respect to bitrate. It has been observed that as bitrate increase from 1.25 to 8.25 Gbps. Average elactrical power decrease from 145.5 x 10^{-8} to 142.5 x 10^{-8}W.

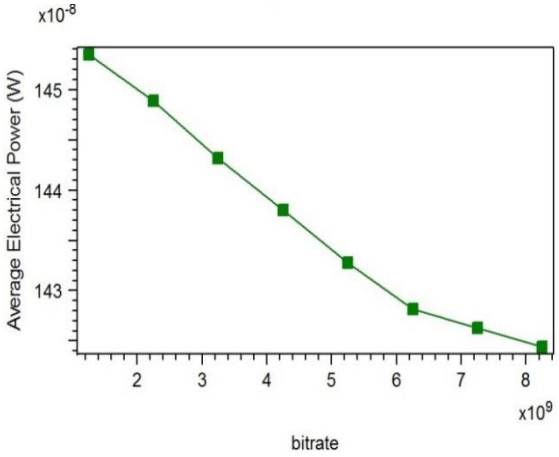


Fig. 7 Average Electrical power vs. Bitrate

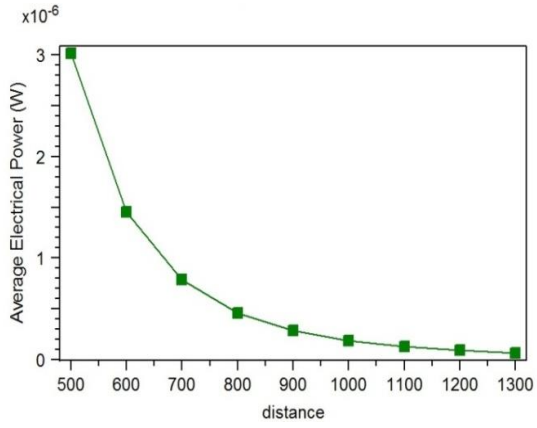


Fig. 8 Average Electrical power vs. FSO distance

Figure 8 shows the varation of average electrical power with respect to FSO distance. It has been observed that as FSO distance increase from 500 to 1300m. Average electrical power decrease from 3 x 10^{-6} to 0.3 x 10^{-6}W.

Figure 9 shows that variation of average electrical power with respect to additional attenuation. It has been observed that as additional attenuation increase from -8 to-2 dB. Average elactrical power will be increase from 0.9 x $10^{-6}$to 13 x 10^{-6}W.

Figure 10 shows that variation of average electrical power with respect to fiber distance. It has been observed that as fiber distance increase from 15 to 30 km. Average elactrical power decrease from 13 x 10^{-7} to 3 x 10^{-7}W.

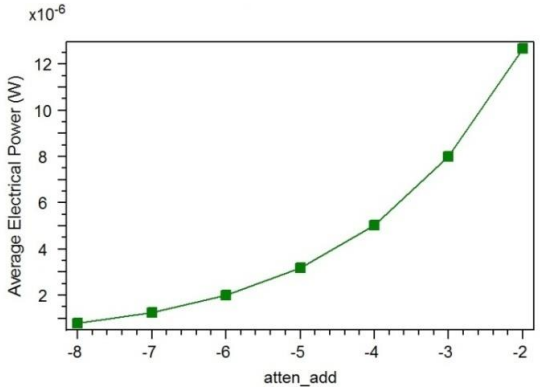


Fig. 9 Average Electrical power vs. Add. Attenuation

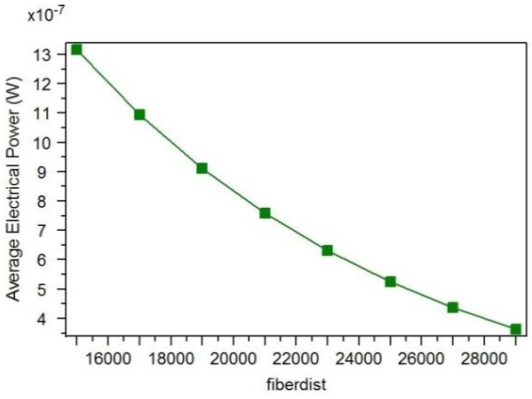
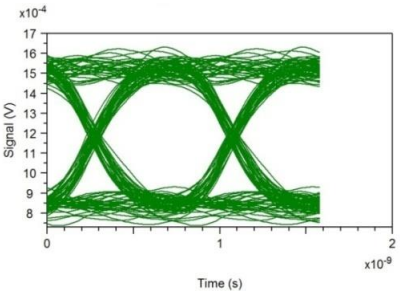
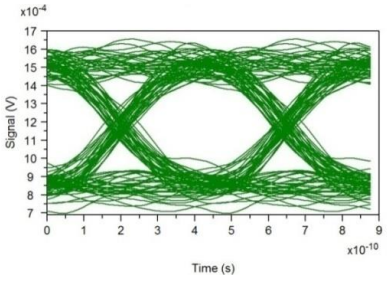


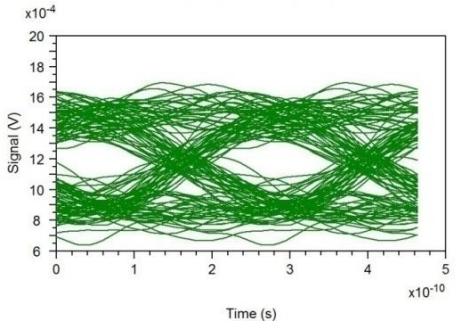
Fig. 10 Average Electrical power vs. Fiber distance



(a)

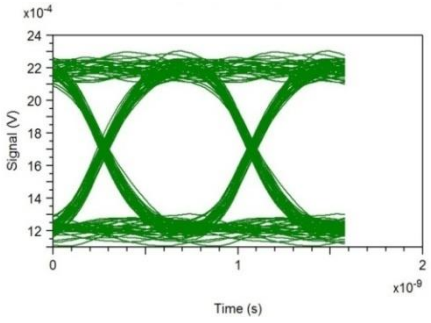


(b)



(c)

Fig 11: Eye Diagram at bit rate of (a) 1.5Gbps (b) 2.5Gbps (c) 4.5Gbps



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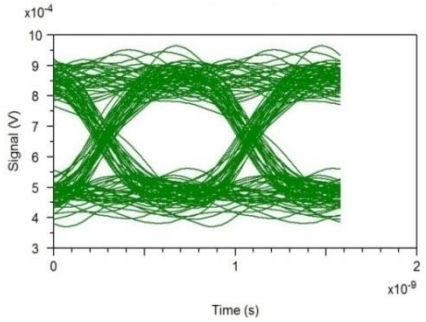
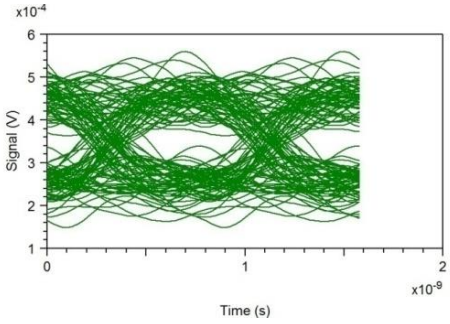


(b)



(c)

Fig12: Eye Diagram for FSO distance at (a) 500m (b) 800m (c) 1100

Figure 11 shows the as bit rate is increased from 1.5Gbps to 8.25Gbps. Eye diagram opening has been reduced and signal quality is also reduced.

Figure 12 shows the as FSO distance increase from 500m to 1300m. It has been observed that eye diagram opening has been reduced.

IV. CONCLUSION

In this paper a hybrid network based on RoF & FSO is developed and its performance is investigated under various parameters. It is observed that network provides acceptable BER of 10^{-8} over a distance of 27 km of fiber within the range of 1.25 to 3 Gbps. On the other hand quality free space transmission is limited up to 800 meter only. It is also reported from eye diagram that signal power and transmission quality reduces significantly beyond 4.25 Gbps data rate and 1100 meter of free space distance. Further network performance can be improved by optimizing the free space channel attenuation parameters.

REFERENCES

[1] In Keun Son and Shiwen Mao, "A Survey of Free Space Optical Network," Digital Communication and Networks, November 2016.

[2] Hemani Kaushal and Georages Kaddoum, "Optical Communication in Space: Challenges and Mitigation Techniques", IEEE Communication Surveys & Tutorials, 2016.

[3] Mohammad Ali Khalighi, Senior Member, IEEE and Murat Uysal, "Survey on Free Space Optical Communication: A Communication Theory Perspective", IEEE Communication Surveys &Tutorials, Vol.16, No. 4, Fourth Quarter 2014.

[4] A Mansour, R.Mesleh, M.Abaza, "New Challenges in Wireless and Free Space Optical Communications," ELSEVIER, March 2016.

[5] Abhimanyu Nain, Suresh Kumar, Shelly Singla, "Mitigation of FWM induced crosstalk in WDM RoF systems by employing different fibers," Journal of Optics, vol. 46(4), pp. 492-498, December 2017.

[6] Hao Chi and Jianping Yao, Senior Member, IEEE Member, OSA, "Frequency Quadrupling and Up conversion in a Radio Over Fiber Link , " Journal of Light wave Technology, Vol. 26, No. 15, 1 August 2008.

[7] Abhimanyu Nain, Suresh Kumar, Shelly Singla, " Impact of XPM Crosstalk on SCM-Based RoF Systems," Journal of Optical Communications, Vol. 38 (3), pp. 319-324, 2017.

[8] Varghese Antony Thomas, Mohammed El-Hajjar, and Lajos Hanzo,"Performance Improvement and Cost Reduction Techniques for Radio Over Fiber Communications," IEEE Communication Surveys & Tutorials, Vol. 17, No. 2, Second Quarter 2015.