Simulative Comparison of Various Modulation Techniques in RoFSO based Networks

Garima Nain[1] & Abhimanyu Nain[2]
[1]Research Scholar, Deptt. of ECE, GJUS&T Hisar, India.
[2*]Assistant Professor, Deptt. of ECE, GJUS&T Hisar, India.

Received June 21, 2017 Accepted July 18, 2017

ABSTRACT *Radio over free space optics (RoFSO) is an emerging technology which can be used as an alternative to Radio Communication. It is a suitable technique for in campus communication and to meet the demand of increasing capacity and quality of service (QoS). Various types of modulation schemes are in existence to modulate the light signal. In this paper, performance of different modulators like Electron absorption modulator (EAM) and Mach-Zehender Modulator (MZM) is compared. The analysis is done for a distance of 2 km and considering various parameters like bit rate, receiver aperture area, additional attenuation etc. It is observed that MZM & EAM yields a bit error rate (BER) of 10^{-26}& 10^{-12} at a transmission distance of 1 km respectively. MZM produces output with 5 dB higher power compared to EAM. It is also revealed that increasing the bit rate from 2 to 6 Gbps increases the BER significantly for both MZM & EAM. Further, it is seen that increasing the aperture area improve the performance as BER is decreased. Eye diagrams are also observed which show the MZM based signal provides improved performance over EAM.*

Key words: *RoFSO, EAM, MZM, BER.*

Introduction

The world of communication is changing at great pace**.** The optical fiber backhaul is being used to provide services like Wi-Max [1]. Radio over Fiber (RoF) technology has shown remarkable growth in wireless mobile communication due to its numerous advantages [2].An insatiate demand of bandwidth in market brings Free-Space Optics (FSO) technology in existence. Radio over Free space optics (RoFSO) is a type of technology in which radio frequencies are transmitted in the form of light over free space [3]. RoFSO is advancement over radio communication in terms of capacity and bandwidth. It is an achievement over optical fiber communication where data is transmitted with the help of optical fiber cable network but FSO made the system wireless. Optical link uses laser and LED as light source though data rate for both sources is different. Low data rate over short distance is possible using LED and long distance can be covered using a source which has high coherency & monochromatic properties like Laser. FSO system is unlicensed with frequencies in the range of hundreds of terahertz. The area of application of FSO is increasing day by day like [4].

- Campus communication networks
- Military applications
- Alternate to fiber applications
- Metro MAN network is being extended using FSO

FSO offers high speed connectivity in Gbps range which is very high in comparison with any other system. The performance of RoFSO system depends upon the type of modulator used like internal modulation & external modulation. In general various types of modulators can be used like MZM, Optical Phase Modulator (OPM) and EAM [5]. But MZM and EAM modulators are used extensively.

A Mach-Zehender modulator (MZM) is used to maintain the amplitude of optical signal. The input signal is divided into two paths, one of these paths is phase shifted after division and when both the parts recombined the phase difference between them results in amplitude modulation. An electron absorption modulator (EAM) is also used for modulating Laser beams. It works on the basis of change in material absorption with change of electric field. It provides high data rate with low noise. It has certain advantages like low voltage of operation and large bandwidth [6].

The error rate performance of free-space optical (FSO) links over strong turbulence fading channels together with misalignment effects has been discussed in [7]. In [8] it has been concluded that the increment in range, angle, distance, vision & frequency etc. influence the attenuation. The receiver structure using saturated optical amplifiers causes a significant reduction in scintillation index and as a result, a reduction of BER up to three orders of magnitude is observed. Apart from this, performance of various amplifiers like EDFA and SOA has been investigated in [9]. As the demand for ultra fast wireless communication networks is increasing rapidly, RoFSO seems to be a viable solution especially for line of sight communication systems. In this paper the performance of EAM and MZM based modulation techniques are compared for campus area network.

Simulation Setup

This section provides details of simulative model designed for analyzing the performance of modulators.OPT SIM simulator is used to investigate the performance of FSO system. Figure1 presents the developed simulative model.

The CW laser is modulated using MZM and EAM. Bit rate for data transmission is varied from 2 to 6 Gbps over a transmission distance of 2 Km. Performance of both the modulators is compared in terms of BER, received power, Eye diagram etc. The range of simulative parameters is kept same for both modulators.

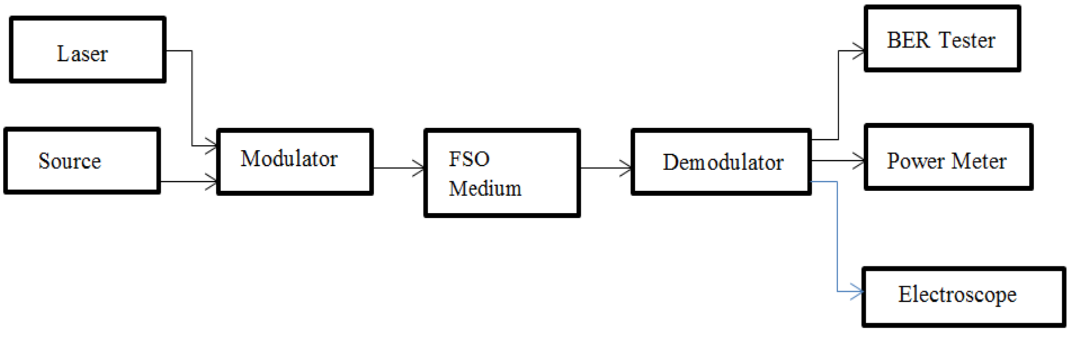


Fig.1: Block diagram of developed model

Additional attenuation of FSO block is -4 dB at a wavelength of 1550nm and the beam divergence is varied from 0.2 to 0.6. At the end PIN photodetector is deployed to detect the signal. Various measurement devices such as BER meter, power meter, electroscope etc. are used to observe the output.

Results & Discussions

Figure 2 shows the variation of BER with respect to distance for EAM & MZM modulators. It has been observed that as the distance is increased from 1000 m to 2000 m ,BER increases form 10^{-26} to 10^{-5} for MZM and 10^{-12} to 10^{-1} for EAM. It is seen from the diagram that, MZM supports good transmission up to 1550 m while EAM supports up to 1100 m only.

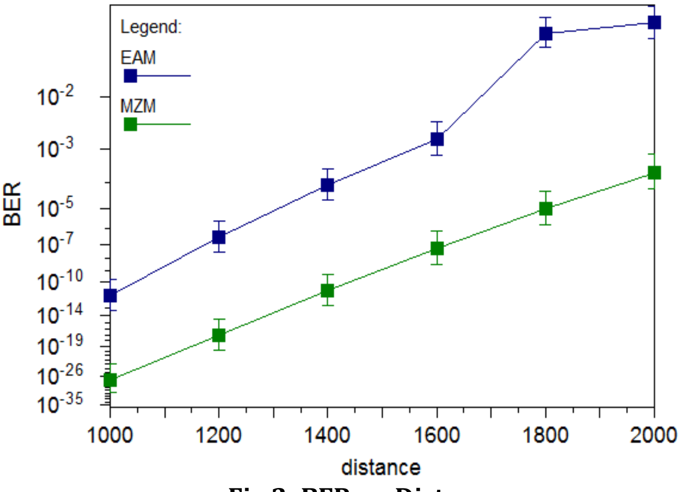


Fig.2: BER vs. Distance

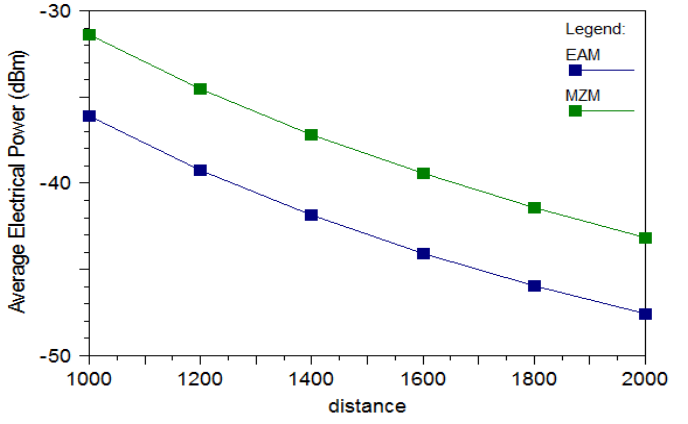


Fig.3: Received electrical power vs. Distance

Figure 3 shows the behaviour of received power with respect to distance for modulators EAM & MZM. It is seen that as the distance is increased from 1000 m to 2000 m, received power varied from -36 to -48dBm for EAM and -30 to -43dBm for MZM. It is testified from the diagram that output power decreases with the increase of distance. MZM yields more output power than that of EAM.

Figure 4 depicts the variation of BER with respect to bit rate for EAM & MZM. It has been observed that as the bit rate increases from 2 to 6 Gbps, BER increases from 10^{-45} to 10^{-1} for MZM and 10^{-16} to 10^{-3} for EAM. Further it is revealed that MZM supports good transmission up to data rate of 4.3 Gbps whereas EAM supports up to 3.2 Gbps only.

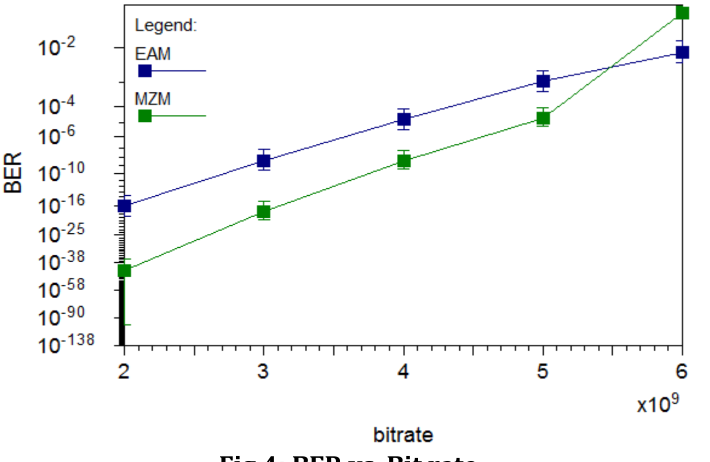


Fig.4: BER vs. Bit rate

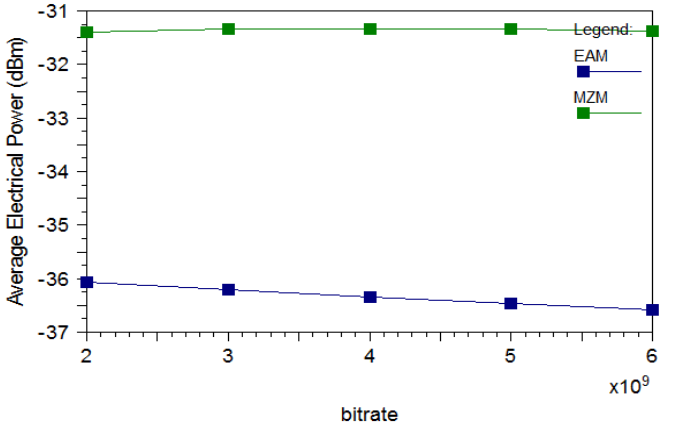


Fig.5: Received electrical power vs. Bit rate

Figure 5 shows the variations of received electrical power with respect to bit rate. It is seen that increment in the bit rate barely offers the received power for both the modulators as the power remains almost unchanged. Though, MZM provides 5 dB higher power than EAM.

Figure 6 shows the variations of BER with respect to receiver aperture area. It has been observed that as the aperture area is varied from 30 sq. cm. to 70 sq. cm, BER decreases from 10^{-5} to 10^{-19} for MZM and 10^{-3} to 10^{-9} for EAM. The figure implies that MZM yields good transmission with aperture area of 47sq.cm while EAM requires 70 sq.cm. to support good transmission.

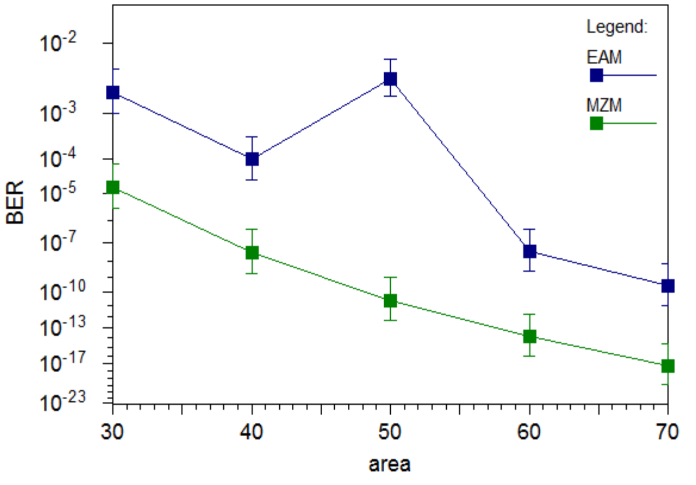


Fig.6: BER vs. Aperture area

Figure 7 shows the variations of avg. electrical power with respect to aperture area for both the modulators. It has been observed that as the area increases from 30 sq. cm. to 70 sq.cm., average electrical power increases from -41 dBm to -37 dBm for EAM and -41.5 dBm to -34.2 dBm for MZM.

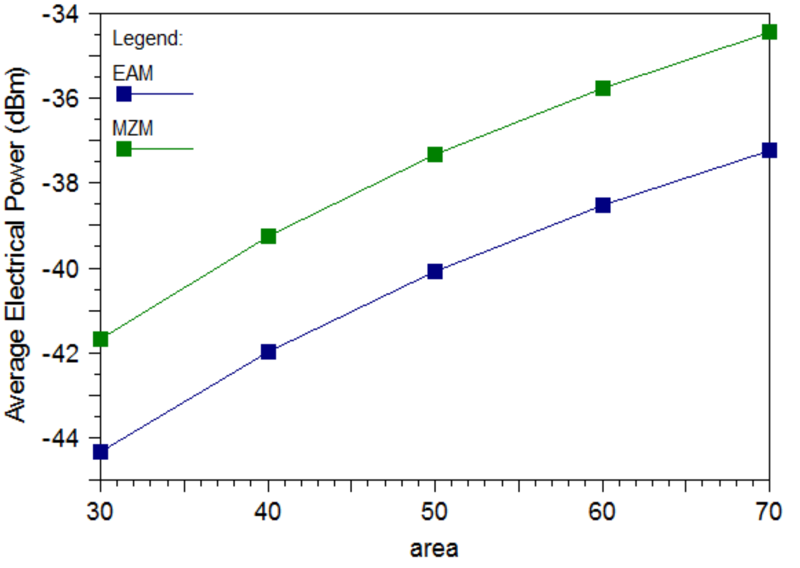


Fig.7: Received electrical power vs. Aperture area

Besides it,effects of additional attenuation on BER for MZM modulator as a function of distance is shown in Figure 8. As the attenuation is increased from -2 to -8 dB, the BER increases from 10^{-138} to 10^{-6}. It is observed that good quality transmission takes place whwn attenuation is lesser than -6dB.

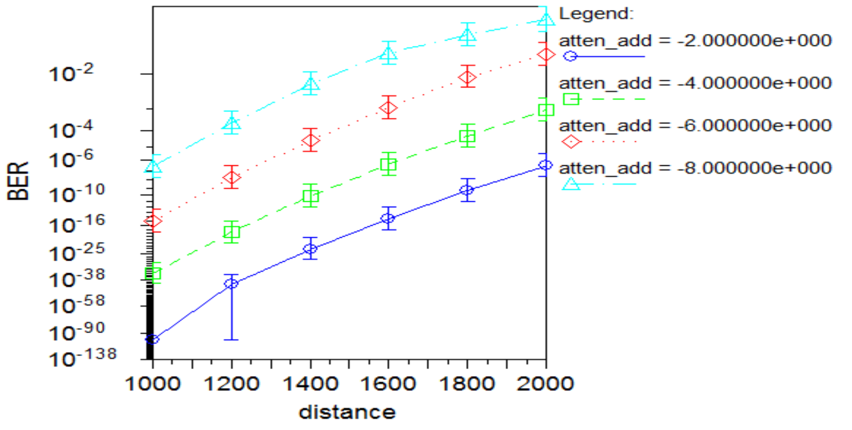


Fig.8: BER vs Distance at varied additional attenuation for MZM

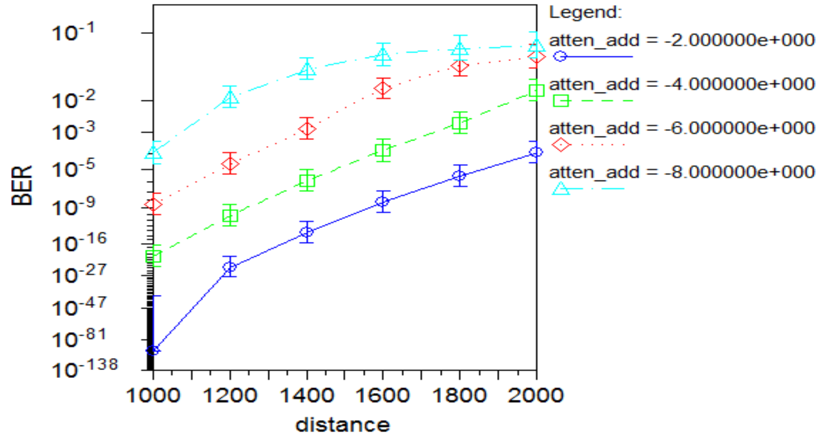
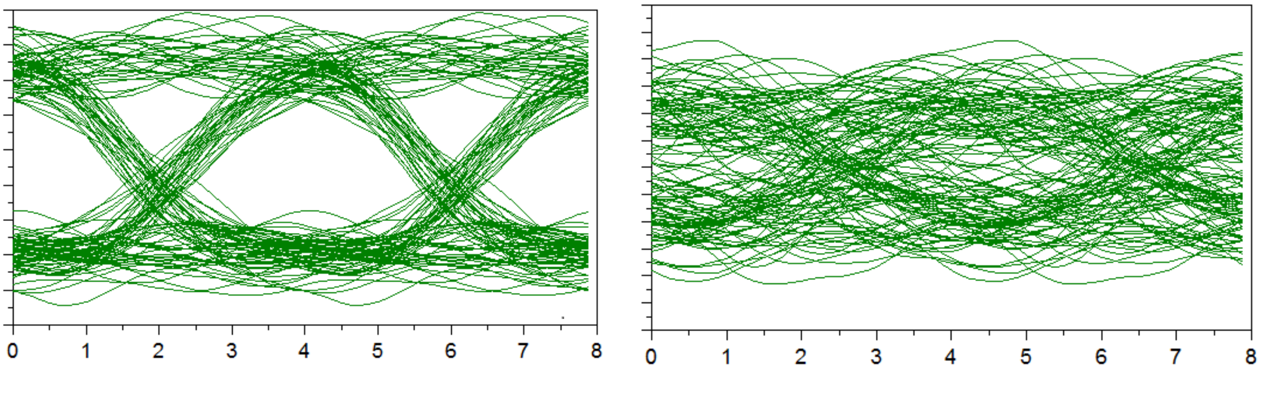


Fig.9: BER vs Distance at varied additional attenuation for EAM

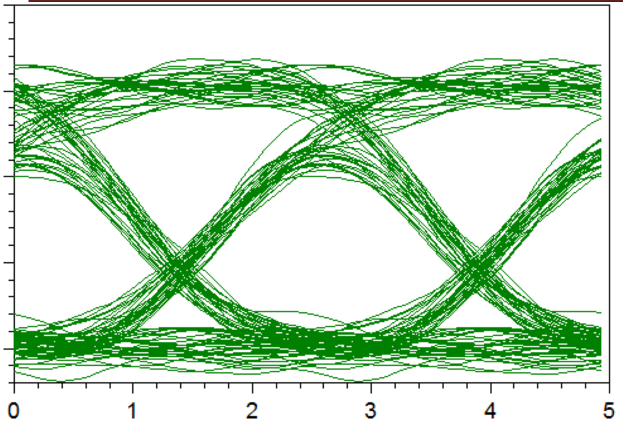
Figure 9 presents the influence of attenuation on EAM modulator. A pattern similar to MZM is observed here. BER increases with increment in attenuation. A favourable transmission is observed for attenuation <-6 dB.

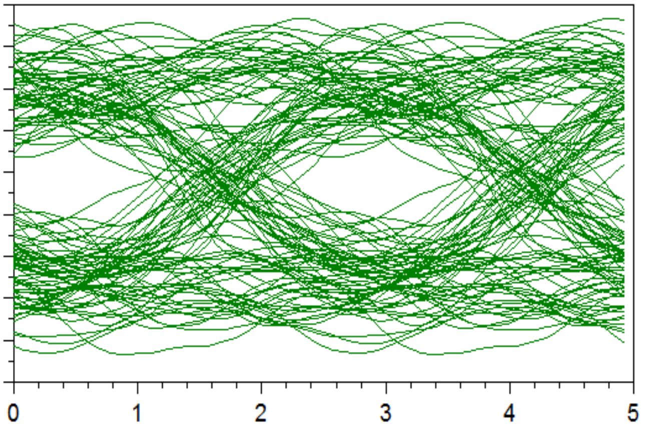
Eye diagrams taken for MZM & EAM based signals at different values of distance,bit rate and aperture area are presented in figure 10,11 & 12 respectively. Eye diagrams offer output in.



(a) **(b)**

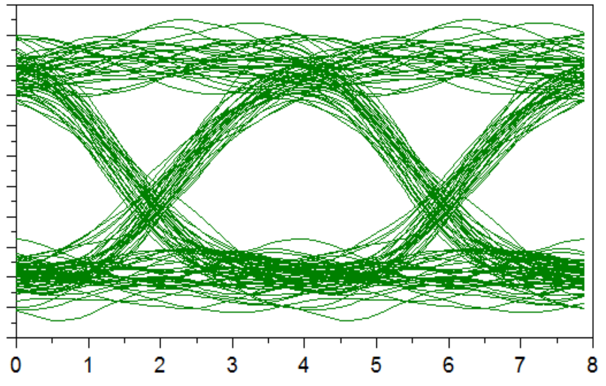
Fig. 10: Eye diagram at a distance of 1.6 km for (a) MZM (b) EAM

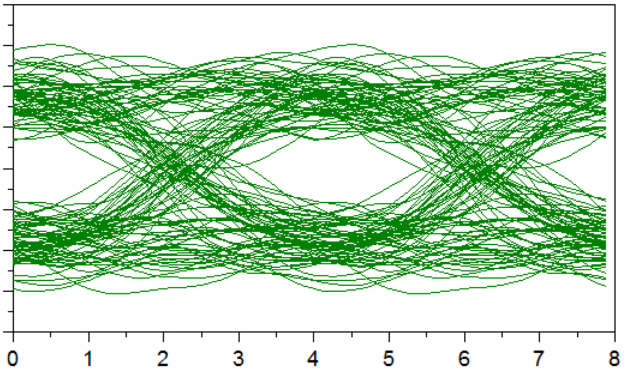




(a) **(b)**

Fig.11: Eye diagram at a bit rate of 4 Gbps for (a) MZM (b) EAM





(a) **(b)**

Fig. 12: Eye diagram at aperture area of 50 sq.cm for (a) MZM (b) EAM

agreement with the previous results. It is observed that MZM based signal transmission is superior to EAM based signal.

Conclusion

RoFSO based links are capable of meeting the continuous increasing demand of data transmission at ultra fast rates. An analysis of MZM & EAM modulators of RoFSO links for campus area networks has been presented. It is concluded that MZM performs better than EAM. MZM can support quality transmission at 500 meter larger distances along with 1.2 Gbps enhanced data rates compared to EAM. Further it yields output with 5 dB higher power. Besides it, eye diagrams observed are in accordance with the theoretical and simulative results, showing the enhanced performance of MZM based transmission.

References

1. Abhimanyu Nain, Suresh Kumar, Shelly Garg , "Wi-Max through RoF: A theoretical study and survey" International Journal of Advance Research In Science and Engineering, Vol.4, Special Issue 01, pp 1310-1317 (2015).
2. Abhimanyu Nain, Suresh Kumar, Shelly Singla, "Mitigation of FWM induced crosstalk in WDM RoF systems by employing different fibers" Journal of Optics, DOI 10.1007/s12596-017-0413-2 (2017).
3. K. Kazaura, K. Wakamori, M. Matsumoto, T. Higashino, K.Tsukamoto and S. Komaki, "RoFSO: A universal platform for convergence of fiber and free-space optical communication networks,"

Communications Magazine, IEEE, vol. 48, pp. 130-137(2010).

4. Juan C. Juarez, Anurag Dwivedi, A. Roger Hammons, Jr., Steven D. Jones, Vijitha Weerackody, and Robert A. Nichols, "Free-Space Optical Communications for Next-Generation Military Networks", IEEE Communications Magazine, 46 doi: 0163-6804/06 (2006).
5. Hao Chi, Xihua Zou, Jianping Yao. Analytical Models for Phase-Modulation-Based Microwave Photonic Systems With Phase Modulation to Intensity Modulation Conversion Using a Dispersive Device, Journal Of Lightwave Technology. Vol. 27(5), Pp 511-521 (2009).
6. Pooja Gopal, V.K.Jain and Subrat Kar, "Spectral analysis of intensity modulation schemes in free space optical communications", IET Communications, Vol.9, No.7, Pp 909-916 (2015).
7. Harilaos G. Sandalidis, Theodoros A. Tsiftsis, George K. Karagiannidis,and Murat Uysal,"BER Performance of FSO Links over Strong Atmospheric Turbulence Channels with Pointing Errors", IEEE Communication Letters, Vol. 12, No. 1 (2008).
8. Abdulsalam G. Alkholidi, Khalil S. Altowit,"Climate effects on performance of free space optical communication systems", Frontier of Optoelectronics (2014).
9. Mohammad Abtahi, and Leslie A. Rusch,"Mitigating of scintillation noise in FSO communication link using saturated optical amplifier", IEEE Military Communications Conference, MILCOM (2006).

A human being is not attaining his full heights until he is educated.
~ Horace Mann