Performance Analysis of 32x10gbps HOA DWDM System Using Different Modulation Formats

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***Abstract* - In this work, Performance analysis of Hybrid optical amplifier in 32x10Gbps WDM system has been studied at varied input power, pump power and core radius of Raman fibre. It is observed that gain of HOA increases with the increasing pump power, but noise figure also increases. Also at varied input power, better results has been reported at low input power -26dB and gain >45dB with <7.4 dB noise figure is reported. Further system performance analyzed using different modulation formats i.e. NRZ, RZ, CSRZ, MDRZ and DPSK.DPSK format observed best and covered link distance 1690Km.**

***Keywords* - HOA,Haul, LASER, Compensation**

I. INTRODUCTION

Innovations in the communication system have increased the demand for large bandwidth to send maximum data at rapid speed. The solution for this demand of higher bandwidth is provided by Optical communication technology [1]. In the optical fiber, the signal degrades as the transmission distance is increased due to the presence of various non-linearities [2]. So, there is demand of optical amplifiers which provide better performance for DWDM system. Advance modulation format gives the better result by using optical amplifiers in DWDM (Dense Wavelength Division Multiplexing system) [3]. besides the basic modulation format that are RZ (return to zero), NRZ (non return to zero) which studied included advance modulation formats CSRZ (carrier-suppressed return to zero), DRZ (duo binary return to zero), MDRZ (modified duo binary return to zero) operate better in WDM (wavelength division multiplexing) [4].As signal travels in optical domain in DWDM system so we need a type of amplifier which can directly amplify signal in optical domain. These types of amplifiers are known as optical amplifiers. Some examples of these amplifiers are EDFA, RAMAN, SOA, Hybrid optical amplifiers etc. But nowadays Hybrid optical amplifiers are more popular. DWDM systems work on the mathematical model which is two-dimensional (time and wavelength), discrete-time, and individually characterizes physical layer impairments[5]. Whereas, long-haul optics refers to the transmission of observable light signals over optical fiber cable for large distances, especially with or without minimal use of repeaters. Normally, repeaters are required after some time in a span of fiber optic cable to remain the signal quality from weakening to the point of non-usability. In long-haul optical communication system, the objective is to keep the number of repeaters decrease per unit distance, and most importantly, to render repeaters unnecessary.

A lot of work has been reported in the literature and given as Simranjit singh et al. [6] investigated the performance of four modulation formats return-to-zero , non return-to-zero, return-to-zero raised cosine , non return-to-zero raised cosine by using the different hybrid optical amplifiers in DWDM system . It is reported that RZ-RC and RZ gives the better result by using RAMAN-EDFA hybrid amplifier and cover the large transmission distance that are 1512 and 1260 km. Anu sheetal et al. [7] investigated the DWDM scenario at 40Gb/s with ultra high capacity up to 1.28Tb/s using DRZ, CSRZ and MDRZ modulation formats. Symmetrical compensation is found to be more superior in comparison to pre and post anti dispersion schemes. It is also reported that MDRZ modulation format gives the better result for the transmission distance beyond 1550km.Li Li et al. [8] state that various modulation formats RZ, CS-RZ, and NRZ and in the demodulation and modulation methods of the optical DQPSK are introduced. In 40Gb/s high speed transmission system it investigates various optical signals. It is observed that the ability of anti-PMD (polarization mode dispersion) and anti-dispersion is superior in CS-RZ-DQPSK modulation format.Bosko et al. [9] investigated the UDWDM state at 40 Gb/s using modulation formats such as RZ, NRZ, CSRZ. It is reported that the introduction of a transmission optical filter does not benefit the NRZ modulation format, while it takes gain of the 90 degree polarization launch of neighbouring channels, but still its performance inferior than the RZ and CSRZ in a UDWDM.

In this proposed work, Investigation of HOA in terms of Gain and Noise figure has been studied at varied parameters in order to achieve better and flat gain with minimum noise figure. Further performance of 32x10Gbps HOA system using different modulation formats has been studied in order to enhance the total transmission length with acceptable BER.

II. SYSTEM DESCRIPTION

In this work, Hybrid optical amplifier derived from the combination of EDFA and RAMAN fibre amplifier with system specification as shown in Table 1.

Table.1. System Specifications

Parameters	Values
Data Rate	10Gbps
CW Laser Frequency	192.7-198.5 THZ
Input Power	-26dBm
Laser Line width	0.15MHz
Channels	32
Channel Spacing	100GHZ
Photo detector	PIN
PIN Responsivity	1A/W
Dark Current	10nA

Fig.1 represents the proposed setup of 32x10 HOA systems with dispersion compensation module. In these system 32 channels each carrying 10Gbps data starting from 192.7THz to 195.8THz is used. Spacing between the adjacent channels set to 100GHz to mitigate the effects of crosstalk. A CW laser with input power -26dBm and laser line width 0.15 MHz is used.WDM signal multiplexed with 32:1 MUX followed by hybrid optical amplifier and then transmitted through SMF and dispersion compensation module. Each loop consisting of 50-50 km SMF and 20 km DCF in order to mitigate effects of dispersion. Dispersion compensation fibre length is derived from the formula as given below

$$L_{SMF} * Disp_{SMF} = L_{DCF} * D_{DCF}$$

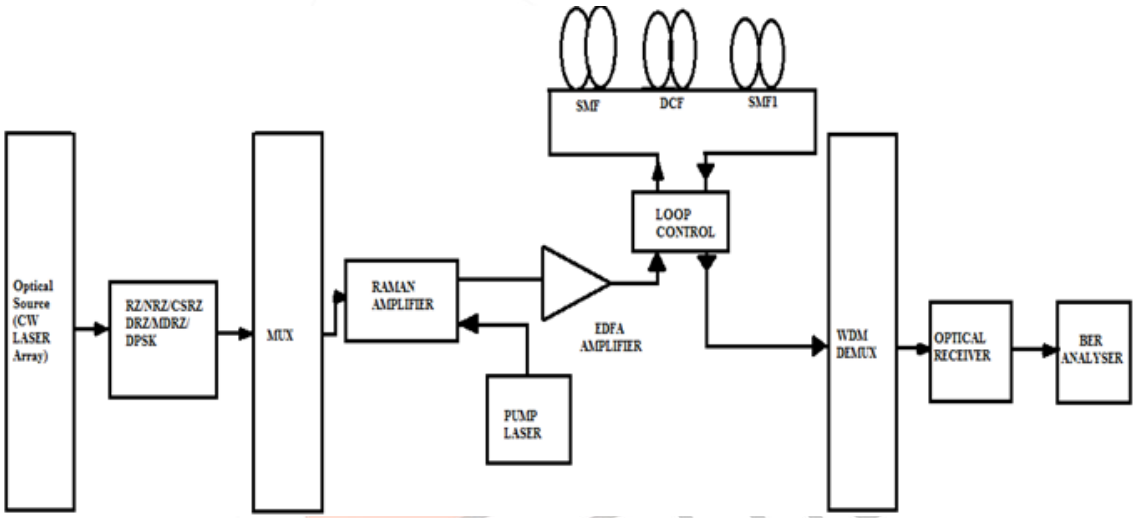


Fig.1. Block Diagram of 32x10 HOA DWDM systems.

Hybrid amplifier gain analysis

The combination of more than one optical amplifier in any configuration is called hybrid optical amplifier (HOA). Mohammed N. Islam described that the net gain of the Raman-EDFA HOA (G_{Hybrid}) is the sum of the two individual gain of Raman and EDFA, respectively [31]. Gain partitioning in hybrid amplifier is as shown in Fig.2.and the HOA specifications given in Table.2.

Therefore, in the case of Raman-EDFA HOA the net gain is:

$$G_{Hybrid} = G_{EDFA} + G_{Raman} \quad (1)$$

The HOAs are an enabling and capable technology for high capacity DWDM systems,

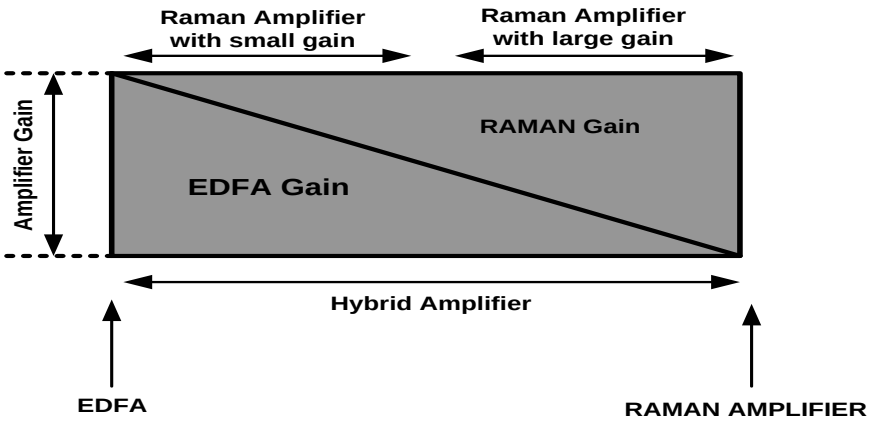


Fig.2.Principle Diagram of HOA

Different specifications of Hybrid Optical Amplifier are listed in the table 2 as follow:

Table.2. HOA Specifications

Parameters	Values
Raman Fiber Length	10Km
Pump power	Varied(500mW,600mW,700mW)
Raman Dispersion	2.75ps/nm/Km
Dispersion Slope	0.075ps/nm^2/K
Temperature	300K
Pump Wavelength	1448.2
EDFA(fixed Gain)	30dB
EDFA NF	4dB

III. RESULTS AND DISCUSSION

Figure.3. represents the power spectrum analyzer for 32x10Gbps WDM system using non return to zero modulation format.Hybrid optical amplifier performance has been studied using varied parameters in order to enhance gain and to reduce noise figure. First of all performance of HOA system studied at different input powers i.e. -26dBm, -10dBm and 0dBm.Graphical representation shown in Fig.4.It is observed that maximum gain analyzed at -26dBm power and as the power increase, Gain decreases. Further HOA performance studied at different core radius and it is prominently observed from Fig.5. that as the core radius decreases, Gain increases and noise figure decreases. At 40um^2 effective core radius maximum Gain of >46dB has been reported with less than 7.4 dB noise figure. Also different pump power play a vital role to flat the gain and reduce the noise. Figure8. Represent that gain increases as the pump power increase. Flat gain and superior results observed at 700mW pump power. Figure 6 and Figure 7 represent the noise figure with respect to the frequency in different core effective area and pump powers respectively

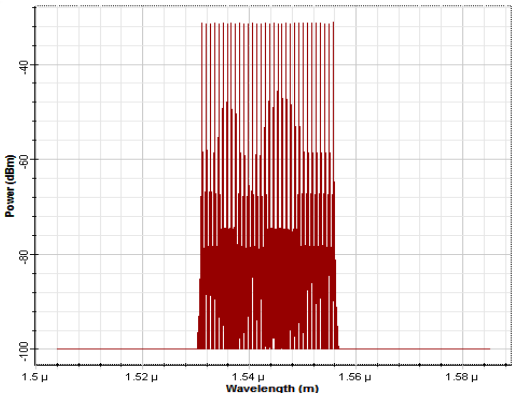


Fig.3.Power Spectrum Analyzer For 32x10Gbps system

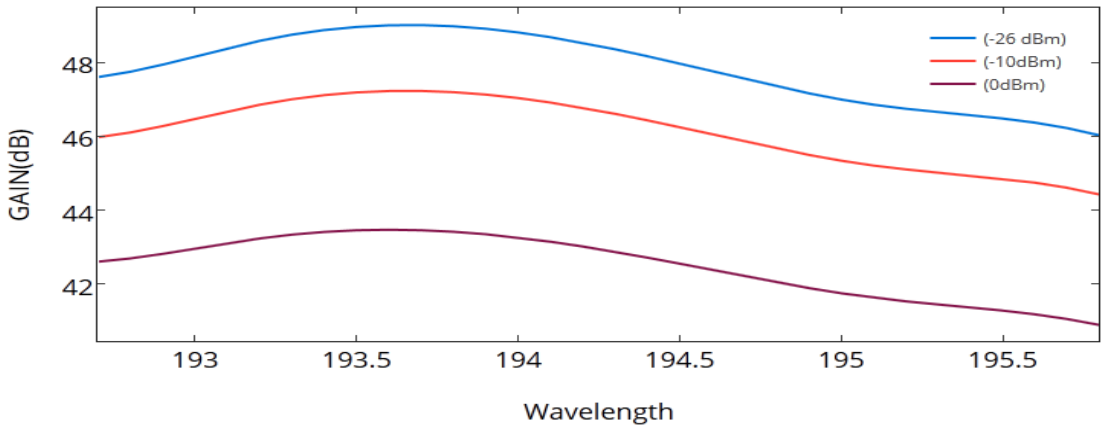


Fig.4.Variation of HOA Gain with different input power

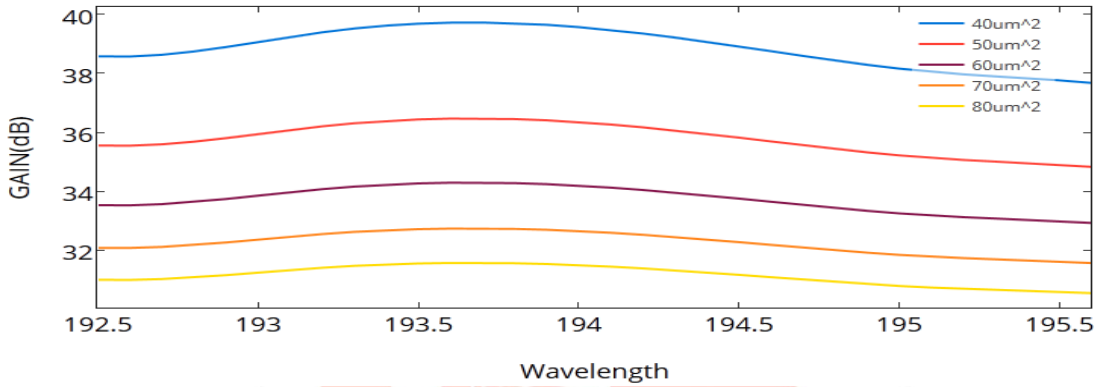


Fig.5.Variation of HOA Gain at different core radius

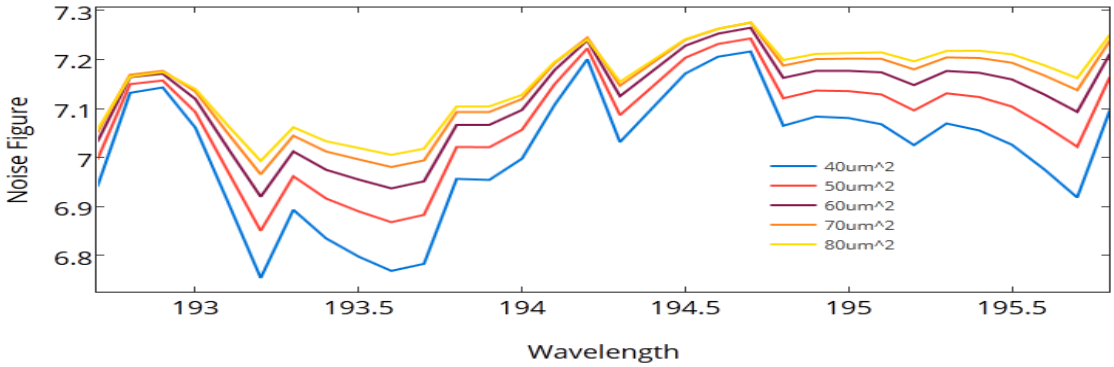


Fig.6.Noise figure Vs Wavelength

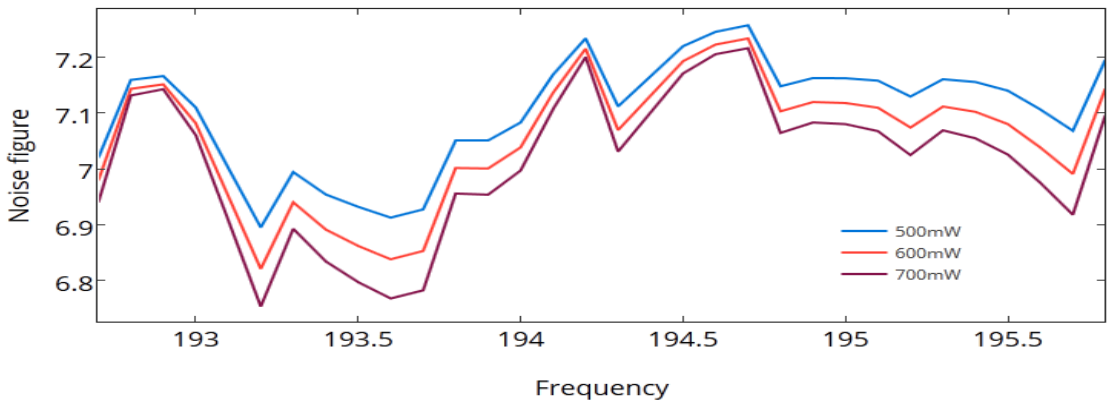


Fig.7.Noise Figure Vs Frequency

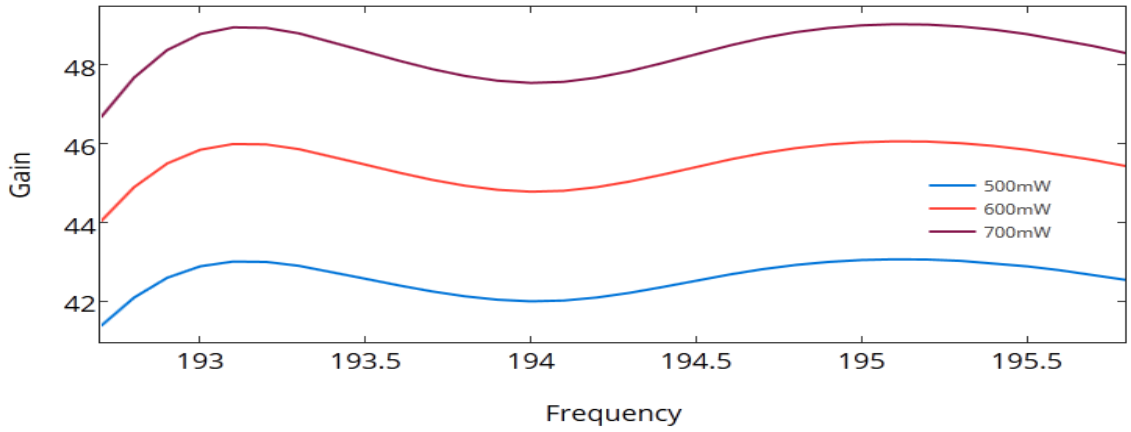


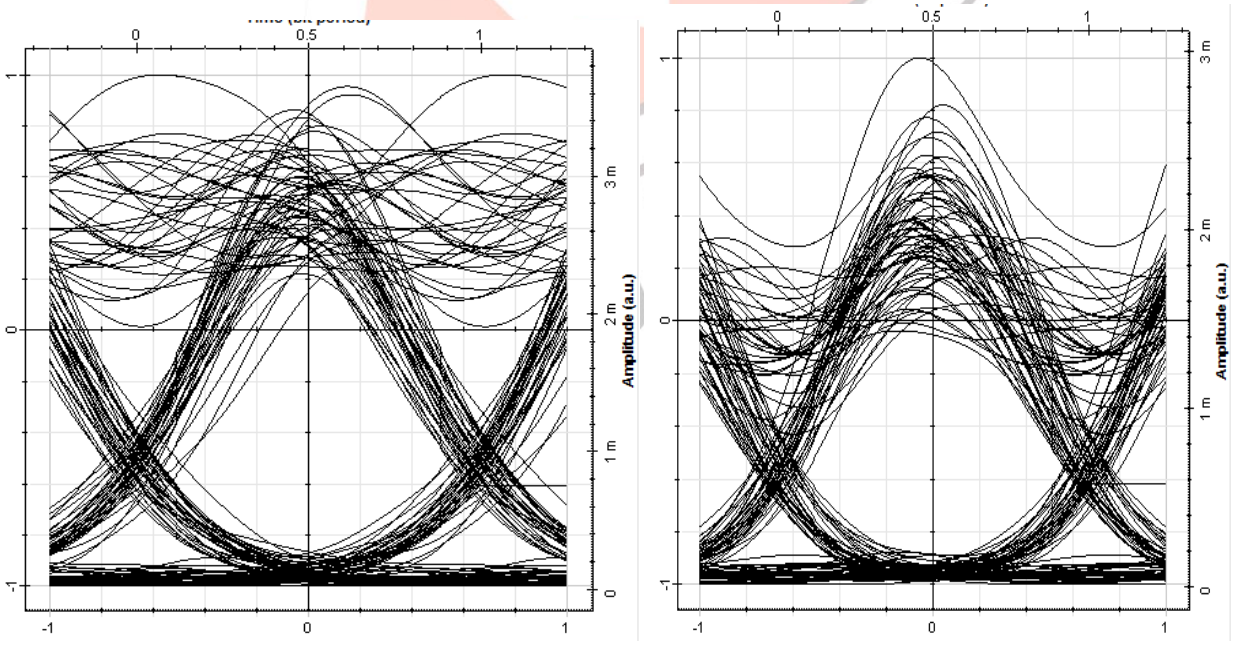
Fig.8.Gain Vs Frequency

It is observed that noise figure decrease and gain of HOA increase, when pump power increase from 500mw to 700mw and change in effective core area varied from 80um^2 to 40um^2.Further performance of HOA is analyzed in WDM system using NRZ, RZ, MDRZ, DPSK and DRZ. It is observed that performance of DPSK is superior to DRZ, MDRZ and NRZ.Table.3.show the values of different formats at 1560Km using propped HOA.DPSK covers the maximum distance of 1690 Km with current HOA scheme.

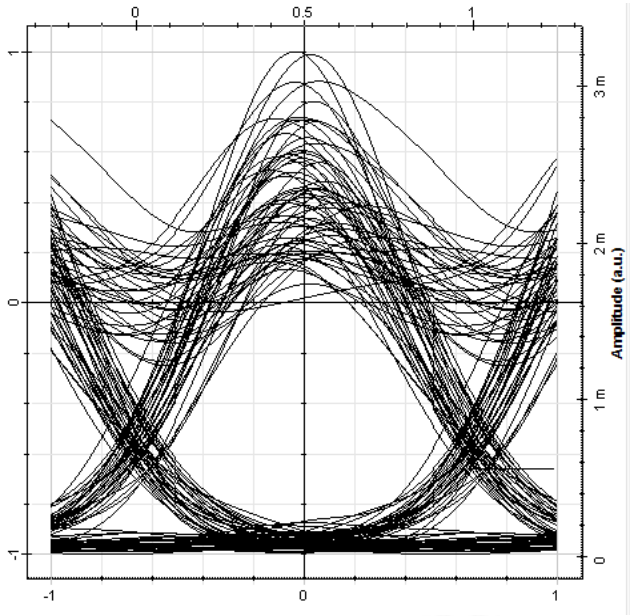
Table.6.Values of different modulation formats at 1560Km with proposed HOA

Modulation format	Q-factor	BER
NRZ	6.02	1.53*10^-10
RZ	5.65	5.09*10^-9
MDRZ	6.10	3.43*10^-10
DRZ	6.21	1.65*10^-11
DPSK	7.58	1.60*10^-14

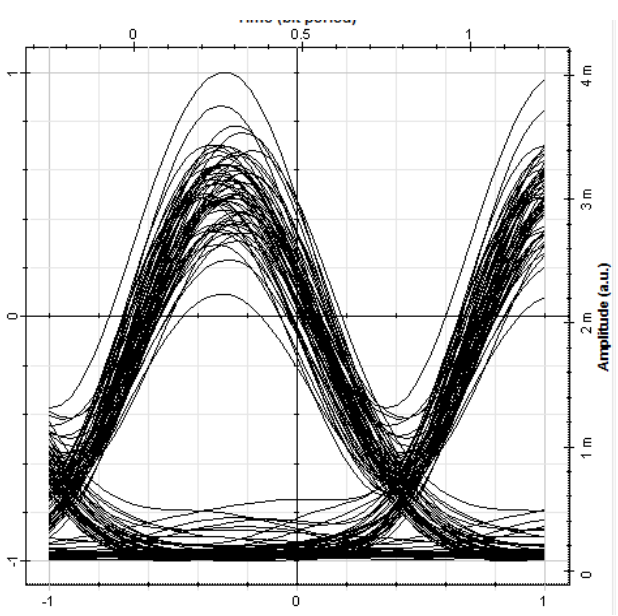
Different Eye Diagrams at 1560Km (a) NRZ (b) RZ (c) MDRZ (d) DRZ (e) DPSK is shown below:



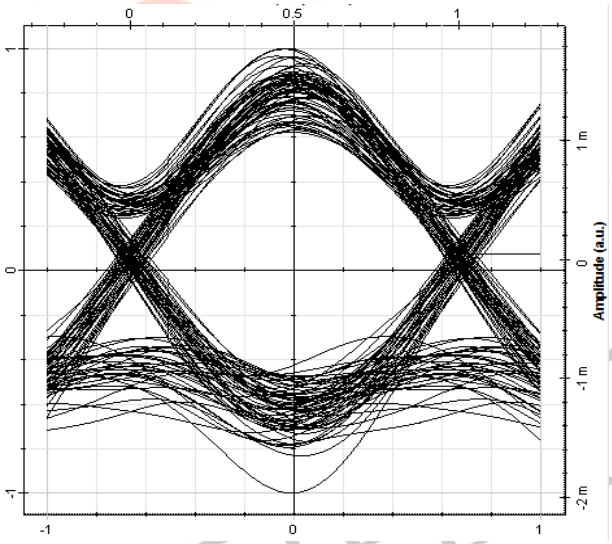
(a) (b)



(C)



(d)



(e)

Fig.9: Eye Diagrams

IV. CONCLUSION AND FUTURE SCOPE

In this work, HOA performance has been investigated by varying pump power, effective core radius and input power of Raman Amplifier Gain of >40dB has been observed with <7.4 noise figure by using minimum power -26dB, pump power 700mw and core radius of Raman fiber 40um^2.Further system performance analyzed using NRZ, RZ, DRZ, MDRZ and DPSK.DRZ and DPSK are found to be best modulation formats with BER 1.65*10^-11 and 1.60*10^-14 at 1560 KM link length. Maximum achievable distance in case of DPSK is 1690Km with acceptable BER.

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