Investigation of DWDM System for Different Modulation Formats

Prabhjeet Singh[a], Narwant Singh[b], Amandeep Singh[c]

[a]B.G.I.E.T. Sangrur, India
[b]G.N.D.E.C. Ludhiana, India
[c]R.I.E.T, Ropar, India

Abstract

In this paper, we investigated the 96×10 Gbps DWDM system with the interval of 100 GHz for different modulation and further compare the performances of these formats in the term of Quality factor and eye closure. It is observed that non-return to zero provide better results amogst other. Further, we covered 190 Km of single span distance using this system with NRZ modulation format.

Keywords: DWDM system, modulation formats, Quality factor, eye closure, BER.

I. Introduction

The current efforts of research and development are aiming at increasing the total capacity of medium and long haul optical transmission systems [1-2]. At the same time, deregulation of telecommunication markets and global success of the internet has driven the demand for higher and higher system capacity. Aihan Yin *et al.* [5] discussed the principals of RZ, NRZ and CSRZ. NRZ has an electrical output signal, which can assume one of the two electrical levels depending on the transmitted bit. When a "1" is fed into the driver, the output signal is at the low level during the entire bit time. When a "0" is fed into the driver, the output signal is at the high level during the entire bit time. RZ has an output signal that can assume two electrical levels. When a "1" is transmitted, the output signal is at the high level for a time equal to the product of the duty cycle by the bit time. Then it goes down to the low level for the remaining time. When a "0" is transmitted, the output is constant at the low level for the entire bit time. Switching between the two levels is instantaneous with resulting square edges.

Toshiya Matsuda *et al.* [8] compared nonreturn-to-zero (NRZ) and return-to-zero (RZ) signal formats for single-channel long-distance transmission in an in-line amplifier system with dispersion management providing average zero dispersion and local nonzero dispersion at an interval equal to the in-line amplifier spacing. It was reported that with linear amplified spontaneous emission (ASE) accumulation, signal waveform distortion due to the combined effect of higher order group-velocity dispersion (GVD) and self-phase modulation (SPM) dominates the performance.

M. I. Hayee *et al.* [9] compared nonreturn-to-zero (NRZ) with return-to-zero (RZ) modulation format for wavelength-division multiplexed systems operating at data rates up to 40 Gb/s. It was reported that in 10–40-Gb/s dispersion-managed systems single-mode fiber alternating with dispersion compensating fiber.

G. Bosko *et al.* [10] investigated the ultra dense wavelength-division multiplexing (UDWDM) scenario at 40 Gb/s using nonreturn-to-zero (NRZ), return-to-zero (RZ), and carrier-suppressed return-to-zero (CSRZ) modulation formats. It is reported that NRZ modulation does not benefit from the introduction of a transmission optical filter, while it takes advantage of the orthogonal polarization launch of adjacent channels. In this paper, we pursue the same target, but in the context 96 channels DWDM system and compare modulation formats such as NRZ, NRZ-RC (non-return to zero raised cosine), RZ and RZ-RC (return to zero raised cosine). Each channel has 10 Gbps data speed.

The paper is organized into four sections. In Section 2, the optical simulation setup is described. In Section 3, comparison results have been reported for the different modulation formats and finally in Section 4, conclusions and future work are made.

3. Simulation Setup

Simulation setup for 96 DWDM channels for different modulation formats is shown in figure1.

As shown in figure 96 signals from CW laser sources, modulated by different modulation formats (Z, NRZ-RC, RZ and RZ-RC) individually, are transmitted over a medium hall link i.e. 50 to 100 Km. The laser power is set to 0 dBm because at higher power the wavelengths tend to overlap each other causing more dominance of non-linar effects like XPM and FWM [1]. The 96 channels (1492.3-1612.7 nm) are spaced at 100 GHz. The input signal spectrum occupies a bandwidth of 120.4 nm. The signals are pre-amplified by a booster and transmitted over DS-anomalous

fiber at 50 to 100 Km of distance. Booster is fixed output power EDFA which has parameters which is set as: output power is 13.9 mW, gain shape is flat and the noise is of 4.5. At the receiver section, the performance of one of the 96 channels (first channel) is evaluated using the optical spectra, eye diagram, BER and Q value measurement.
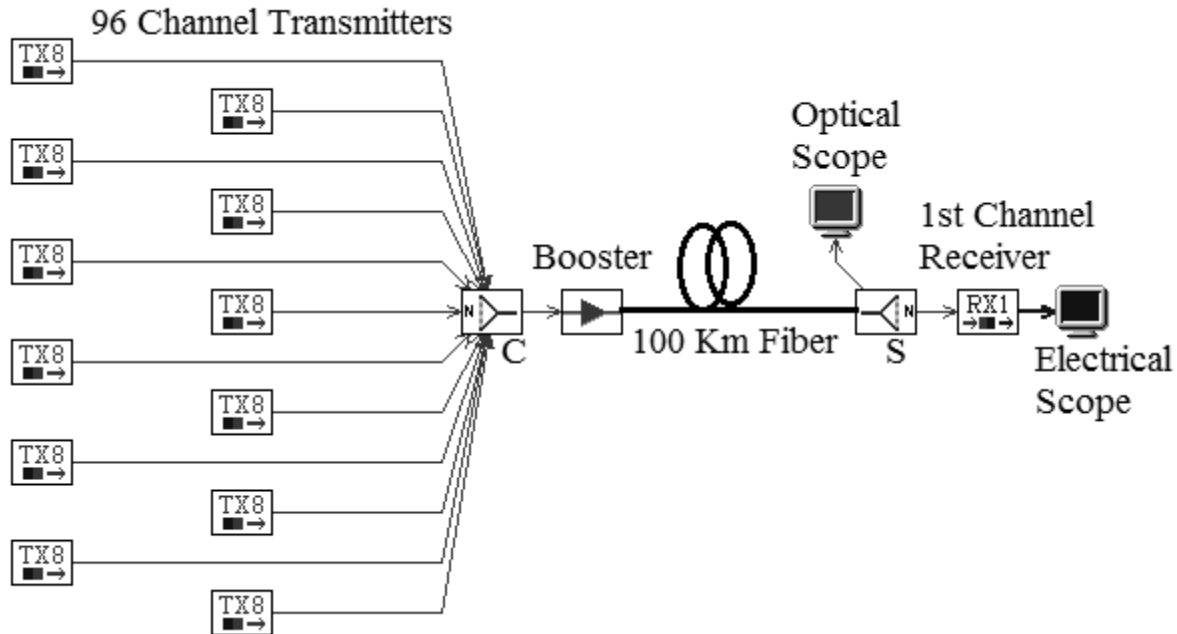

Fig. 1. Simulation setup of 96 channel DWDM system

III. Result and Discussion

The different modulation formats have been compared for 96 X 10 Gbps DWDM system in the term of received maximum Q value (dB) and minimum eye closure. To analyze the system, the results of the first channel have been taken.

The figure 2 shows the graphical representation of Q value as a function of transmission distance. Q value can be seen for all the modulation formats that as the line is vary from 50 Km to 100 Km then the Q-factor is decreased due to the fiber non-linearities. The better Q value is provided by the NRZ data format for the worst case (at 100 Km) it becomes 31.3 dB.
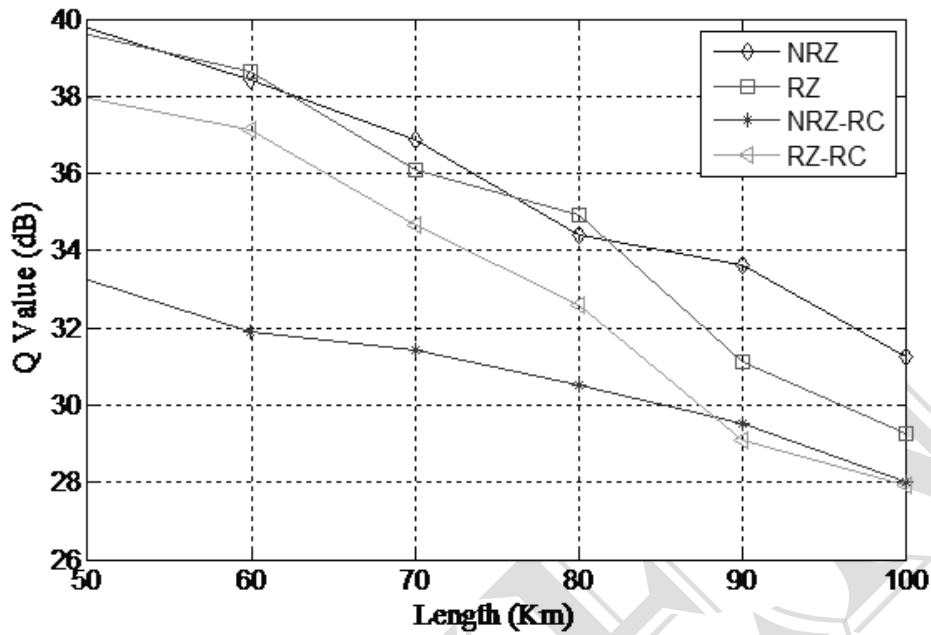
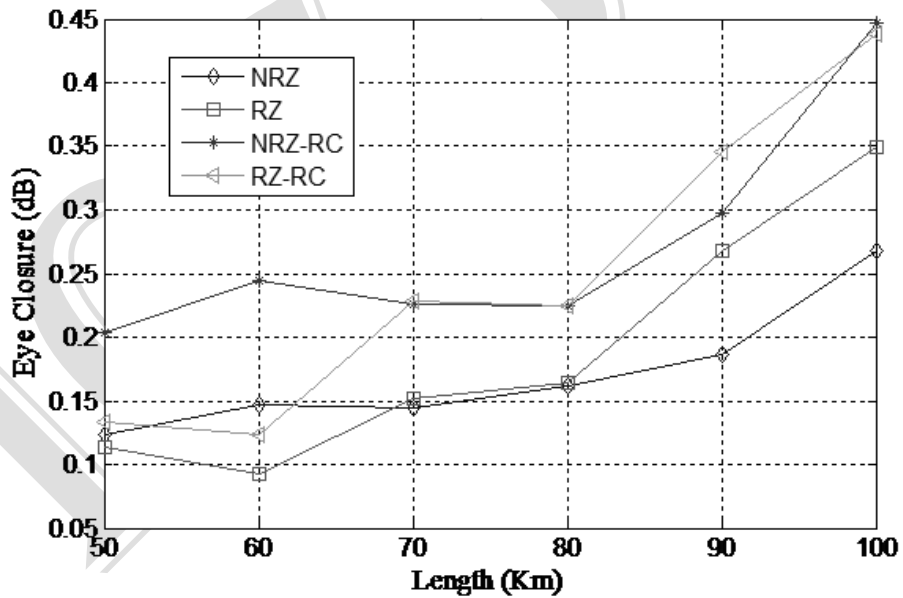Figure 2: Q-Factor versus distance for 64 channels DWDM system.

Figure3: Eye closure versus distance for 64 channels DWDM system.

Figure 3 indicates the eye closure penalty which is high for NRZ-RC and RZ-RC because of ASE noise power. We observed that NRZ provided the least eye closure also in worst case (0.253 dB). Means as we increase the

transmission distance, the eye closure penalty goes on increasing. This shows good agreement with the result [7]. As the eye closure penalty goes on increase, the quality goes on decreasing.

From the previous results it is observed that the NRZ is best alternative than other formats. Then we further find the maximum covered single span distance using NRZ format. From Fig. 4-5 it can see that using this setup we can able to send the data over 190 Km with acceptable Quality factor (15.1 dB), BER (10^{-9}) and eye closure (2.4 dB).
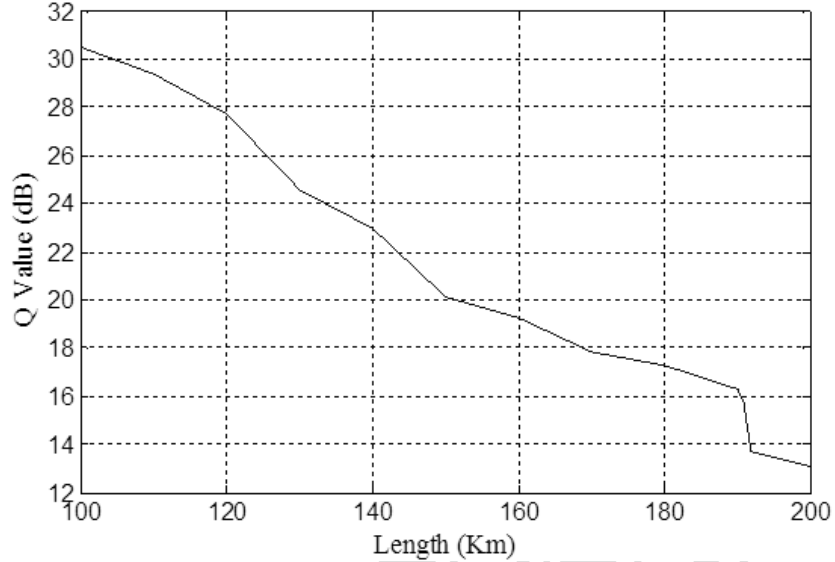

Figure4: Quality factor versus distance for 64 channels DWDM system using NRZ modulation format.
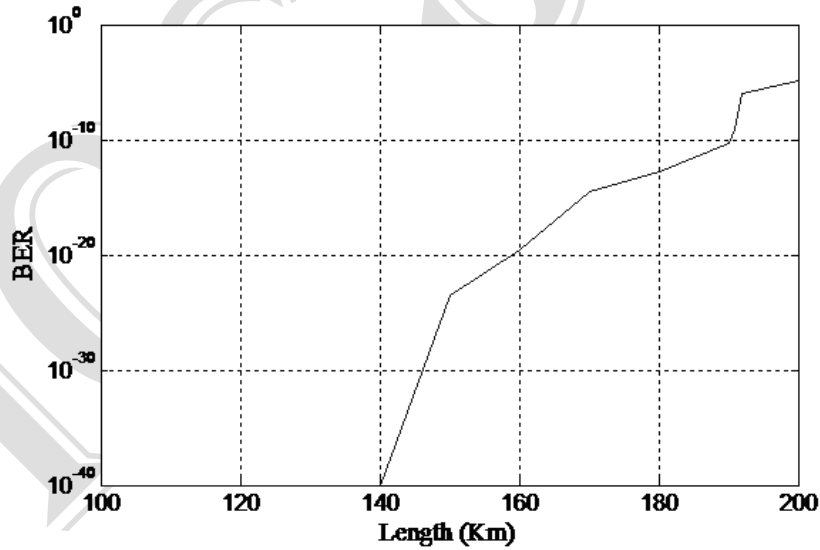

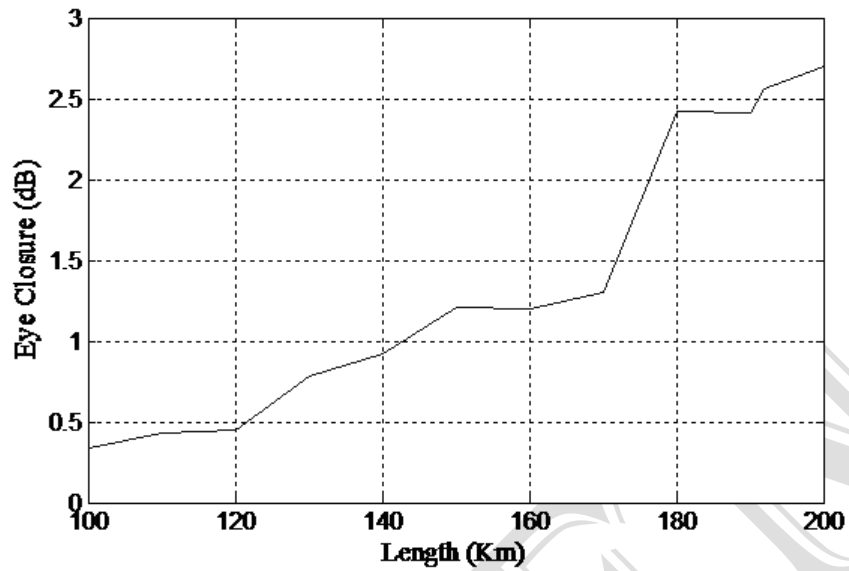Figure 5: BER versus distance for 64 channels DWDM system using NRZ modulation format.
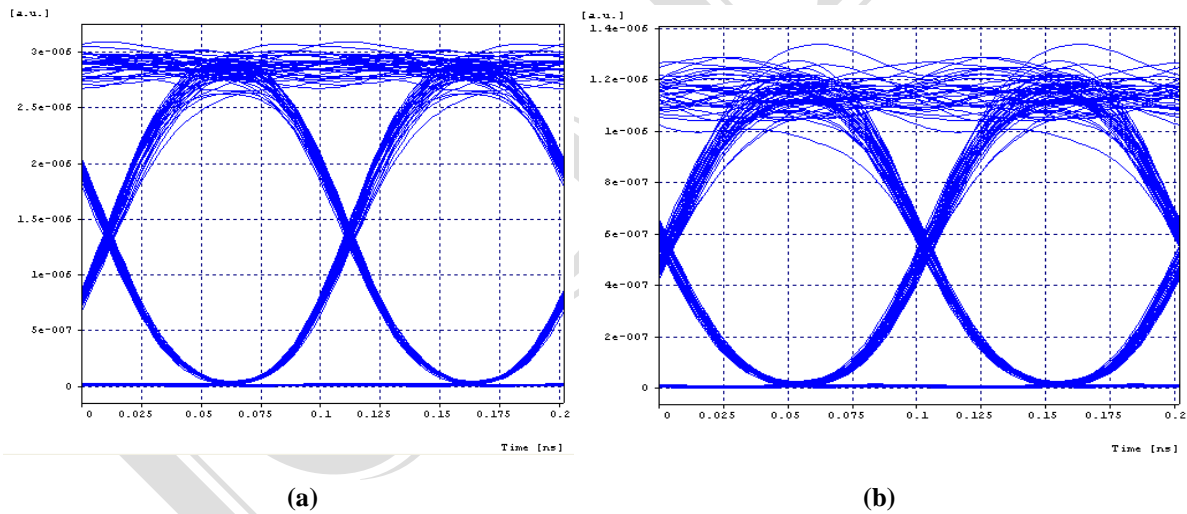
Figure 6: Eye closure versus distance for 64 channels DWDM system using NRZ modulation format.

Now for 96 channels at different distance (110, 130, 150, 170, 190, 200 Km), the eye diagrams are shown in Figure 7.
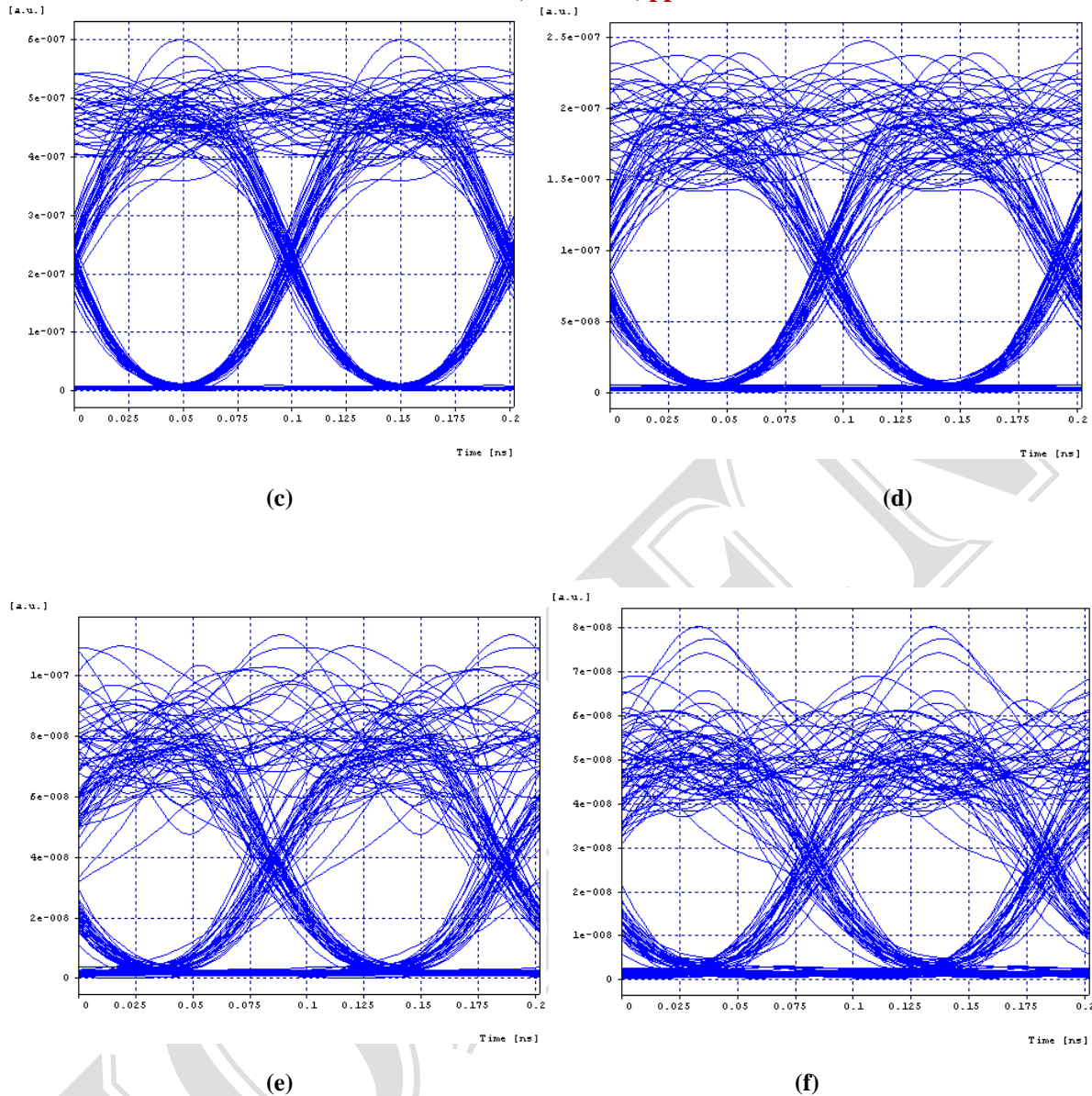

(a)

(b)

(c)

(d)

(e)

(f)

Figure 7: Eye diagrams for 96 channel DWDM system using NRZ modulation formats at (a) 110, (b) 130, (c) 150, (d) 170, (e) 190, (f) 200.

IV. Conclusion

In this paper, we investigated the 96×10 Gbps DWDM system for different modulation and further compare the performances of these formats in the term of Quality factor and eye closure. It is observed that non-return to zero provide better results amogst other which provide better Quality factor (31.5 dB) and Eye closure (0.253 dB) at 100 Km. Further, we covered 190 Km of single span distance using this system with NRZ modulation format.

References

[1] Anu Sheetala, Ajay K.Sharma and R.S.Kaler, "Simulation of high capacity 40 Gb/s long haul DWDM system using different modulation formats and dispersion compensation schemes in the presence of Kerr's effect", Optik—International Journal of Light Electron, Vol. 121, Pages 739-749, 2010.

[2] M. A. Ummy, M. F. Arend, L. Leng, N. Madamopoulos and Roger Dorsinville, "Extending the Gain Bandwidth of Combined Raman-Parametric Fiber Amplifiers Using Highly Nonlinear Fiber", IEEE Journal of Lightwave Technology, Vol. 27, No. 5, Pages 583-589, 2009.

[3] Aihan Yina, Li Li and Xinliang Zhanga, "Analysis of modulation format in the 40 Gbit/s optical communication system", Optik—International Journal of Light Electron, Vol. 121, Pages 1550-1557, 2010.

[4] Toshiya Matsuda, Akira Naka and Shigeru Saito, "Comparison Between NRZ and RZ Signal Formats for In-Line Amplifier Transmission in the Zero-Dispersion Regime", IEEE Journal of Lightwave Technology, Vol. 16, No. 3, Pages 340-348, 1998.

[5] M. I. Hayee and A. E. Willner, "NRZ Versus RZ in 10–40-Gb/s Dispersion-Managed WDM Transmission Systems", IEEE Photonics Technology Letters, Vol. 11, No. 8, Pages 991-993, 1999.

[6] G. Bosco, A. Carena, Member, IEEE, V. Curri, R. Gaudino and P. Poggiolini, "On the Use of NRZ, RZ, and CSRZ Modulation at 40 Gb/s With Narrow DWDM Channel Spacing", IEEE Journal of Lightwave Technology, Vol. 20, No. 9, Pages 1694-1704, 2002.

[7] Surinder Singh and R.S. Kaler, "Placement of optimized semiconductor optical amplifier in fiber optical communication systems", Optik-International Journal of Light Electron, Vol. 119, Pages 296-302, 2008.