Comparative Investigation and Compensating Dispersion Losses in DWDM Systems using EDFA Amplifier for Different Data Formats

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ABSTRACT
In this paper, we have investigated the comparative performance of the dense wavelength division multiplexing system using EDFA amplifier for different data formats i.e. non return to zero rectangular (NRZ-R), non return to zero raised cosine(NRZ-RC), return to zero rectangular (RZ-R) and return to zero raised cosine (RZ-RC) for 384 channels. In the proposed system, optical data is successfully transmitted to a distance of 120 KM. It has been observed that non linearity which severely distorts the signals is produced more in case of RZ-R, NRZ-R and NRZ-RC whereas RZ-RC compensates the dispersion loss variations and hence the best modulation format for the proposed system. Various results are shown to justify these results.

General Terms
DWDM optsim Simulation setup

Keywords
DWDM, EDFA, Modulation formats, NRZ, RZ.

1. INTRODUCTION
Due to large bandwidth provide fiber optical systems have become essential for the global data communication backbone. The requirement of higher data rates over fiber optic links is being fulfilled by dense wavelength division multiplexing (DWDM) [1]. DWDM is used to dramatically increase the capacity of optical access networks and the physical reach is increased significantly from today's usual 20 km (60 km in the case of ITU-T G.984.6 extended reach GPON)[2]. In a DWDM system, the channel is shared by number of users by assigning them unique and different wavelength. These networks consist of multiple semiconductor lasers, each at a unique wavelength, amplifiers like Erbium doped fiber amplifier (EDFA, Raman etc.), DWDM multiplexers and DWDM de-multiplexers, unidirectional/ bi-directional fibers, photo diodes, splitter and combiners etc. The set of different wavelength are generated by the LASER diodes and combined into the channel fiber using a wavelength multiplexer, these wavelengths are demultiplexed at the receiver by photo detectors [3].

L. Marazzi et al. [4] analyzed the continuous-wave (CW) Raman-generated pump impact on a fiber optical parametric amplifier (OPA). Gain and noise figure of the amplifier were calculated. By tightly filtering the CW Raman-generated pump an OPA noise figure approaching the 3 dB limit was achieved. J. Hashimoto et al. [5] discussed the butterfly-type fiber-Bragg-grating external cavity semiconductor laser (FGL) modules to dense wavelength-division multiplexing (DWDM) applications. In a dense wavelength-multiplexing experiment, they demonstrated that successive four-channel multiplexing with 25-GHz spacing and with almost the same peak power was realized by using the FGLs. The lasing wavelength of each channel was tuned to the corresponding wavelength grids with an accuracy of 1 pm. In the DWDM transmission with 25-GHz channel spacing and 2.5-Gb/s direct modulation using a standard single mode fiber (SMF), a good bit-error ratio (BER) performance without floor phenomenon was achieved up to 300 km. D. Dey [3] proposed the concept for building a packet switched MAN with support for multicasting in the optical domain has been presented. Problems such as slot-synchronization (chromatic dispersion), crosstalk accumulation and SNR degradation have been simulated, analyzed and/or experimentally demonstrated.

In literature, various works on DWDM system has been reported. P.J. Urban [6] have demonstrated WDM system having two wavelength channels with data rate of 1.25 Gb/s up to a distance of 26-KM. Till now, we observe that the proposed DWDM systems are limited to lesser number of channels which are transmitted to short distance and comparative investigations of modulation format is not yet done. In this paper, we extended the previous work by increasing the number of channels to long distance. We simulated DWDM system for 384 channels and various modulation formats are compared for these channels for various distances. The data rate is kept 10 Gbps for these systems. This paper is organized into four sections. In Section 1, introduction to DWDM system is given. In Section 2, the simulation setup for these systems is elaborated. In Section 3, results and discussion is given. Finally in Section 4, conclusion of the whole proposed system is made.

2. SIMULATION SET UP
The block diagram of the proposed DWDM system using EDFA amplifiers is shown in Figure 1. The system set up contains a number of components models represented by block icons like transmitter TX, combiner, EDFA, splice, Splitter, and receiver. The combination of combiner, EDFA, splice, Splitter is represented by channel. The setup of transmitter section is shown in figure 2. This setup consists of pseudorandom binary sequence generator (PRBS generator) (which produces data at a rate of 10 Gbps), signal generator (which is used to select desired data format), Bessel filter (to maintain the data in desired band), CW Lorentzian LASER (to convert data in to optical form) and Machzender inferometer modulator (to modulate the data to channel).

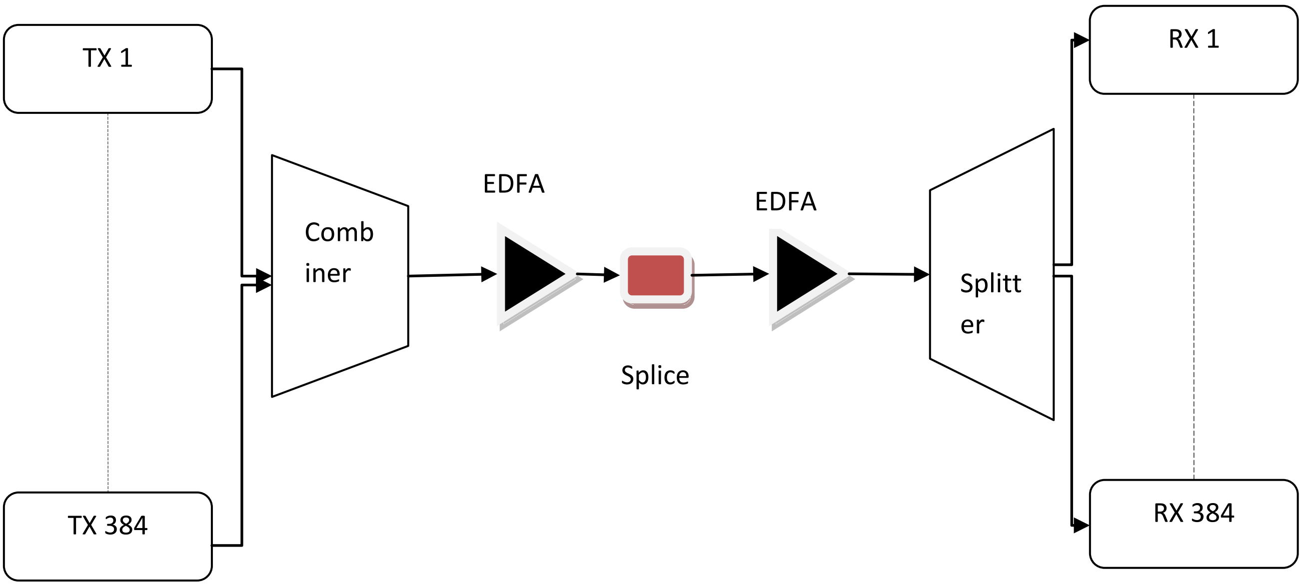


Figure 1 : Block diagram of DWDM system

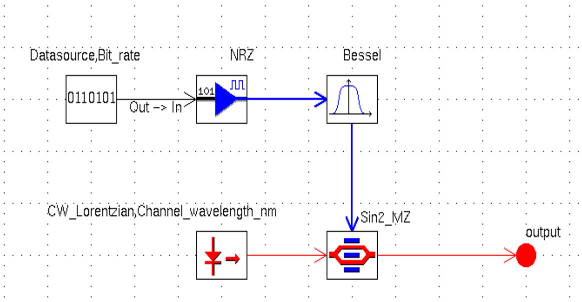


Figure 2: Setup of Transmitter

Various modulation formats like non return to zero rectangular (NRZ-R), non return to zero raised cosine(NRZ-RC), return to zero rectangular (RZ-R) and return to zero raised cosine (RZ-RC) are compared for the proposed system.

The setup of receiver section is shown in figure 3, this section is composed of optical Lorentzain filter, PIN photodiode indicated by the component name RX, PIN and low-pass Bessel filter indicated by the component name Bessel.

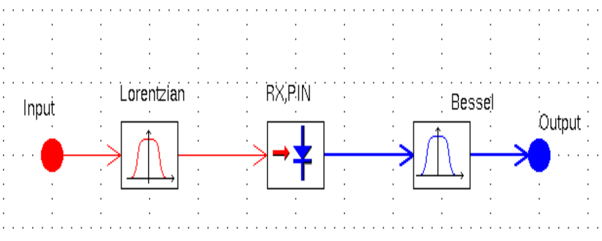
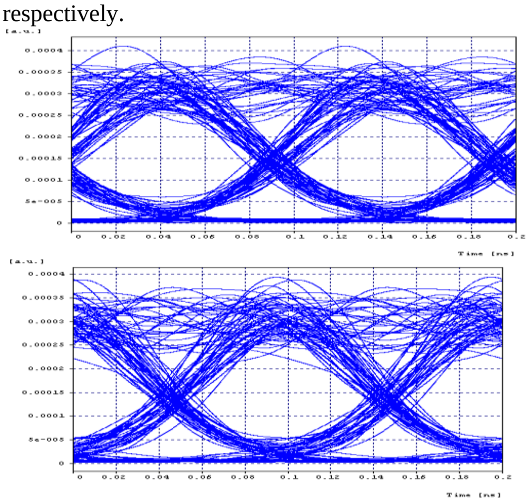


Figure 3: Setup of Receiver

In the proposed system, we have transmitted data with data rate of 10 Gb/s from 384 transmitters, this data is combined and modulated to channel where EDFA amplifier is used for divided the optical link in two identical spans with splice. In first span we use DS normal fiber and in second span we use DS Anomalous fiber to compensate dispersion. Then EDFA amplifier is used as pre amplifier and data is given to receiver. At receiver, 384 users can extract their data, Lorentzian filter is used to assign desired wavelength to individuals. PIN photodiode is used to detect the original data. Various scopes are used to calculate different performance parameters.

3. RESULTS AND DISCUSSIONS

In the proposed DWDM system, data from 384 users is transmitted over the fiber link with different modulation formats for different distance. Various performance parameters like BER, Q factor and jitter is calculated and optical spectrum and eye diagrams are observed. The eye diagrams of DWDM system using 384 users with NRZ-RC at 100, 110 and 120 KM distance is shown in figure 4 (a, b, c) respectively.



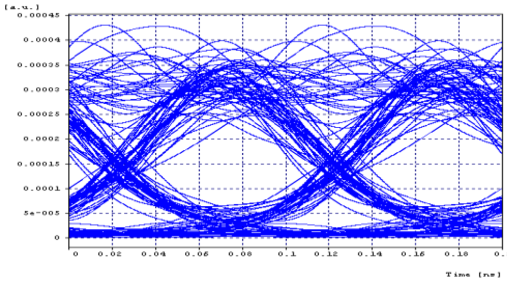


Figure 4 (a, b, c) : The eye diagrams of DWDM system using 384 users with NRZ-RC at 100, 110 and 120 KM respectively

The eye diagrams of DWDM system using 384 users with NRZ-R at 100, 110 and 120 KM distance is shown in figure 5 (a, b, c) respectively.

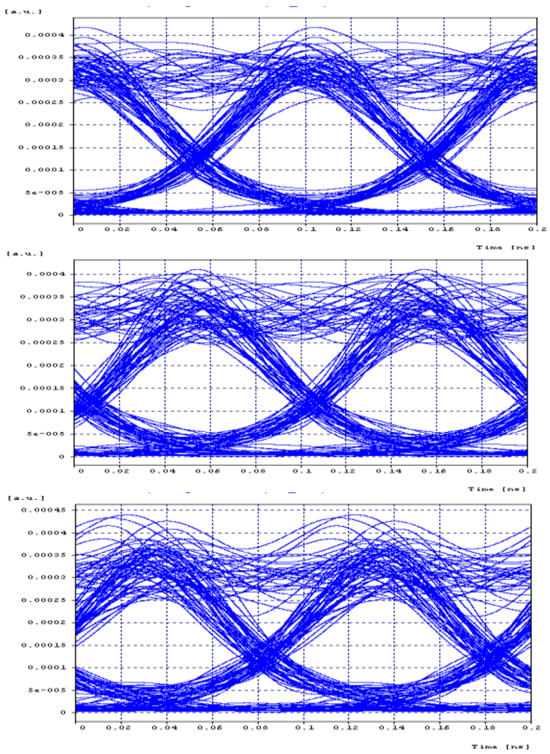
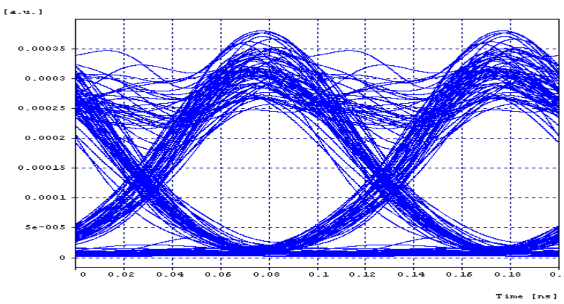


Figure 5 (a, b, c) :The eye diagrams of DWDM system using 384 users with NRZ-R at 100, 110 and 120 KM respectively

The eye diagrams of DWDM system using 384 users with RZ-RC at 100, 110 and 120 KM distance is shown in figure 6 (a, b, c) respectively.



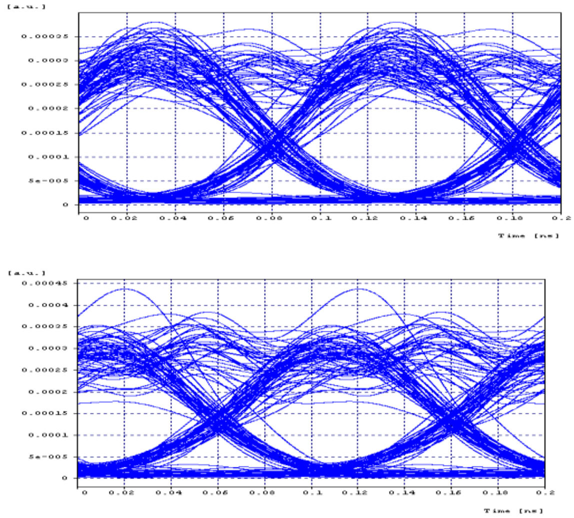


Figure 6 (a, b, c) : The eye diagrams of DWDM system using 384 users with RZ-RC at 100, 110 and 120 KM respectively

The eye diagrams of DWDM system using 384 users with RZ-R at 100, 110 and 120 KM distance is shown in figure 7 (a, b, c) respectively.

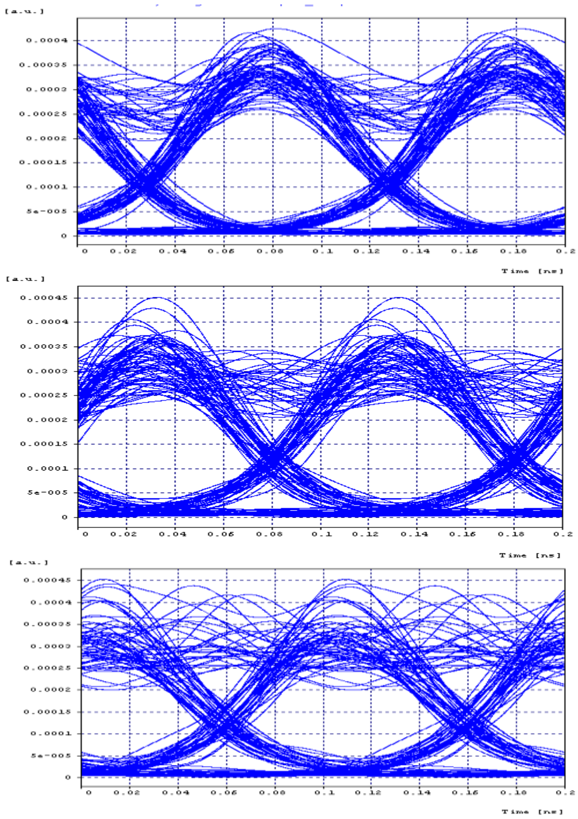


Figure 6 (a, b, c) The eye diagrams of DWDM system using 384 users with RZ-R at 100, 110 and 120 KM respectively

It can be concluded from these eye diagrams that the performance of proposed DWDM system with RZ-RC modulation format is better than all other modulation formats. We can transmit data up to 120 KM with NRZ-R modulation format whereas it is limited to 110 KM in case of NRZ-R, NRZ-R and RZ-R modulation formats. The eye diagrams are distorted more after this distance. The calculated BER, Q factor and Jitter Vs distance is given in the Table 1 for NRZ-R modulation formats

Table 1. NRZ-R modulation formats

Distance in KM	BER	Q factor in dB	Jitter
100	2.01442x10^-12	16.978846	0.018977
110	7.16407x10^-9	15.057962	0.0176629
120	1.46509x10^-7	14.251163	0.0183326

The calculated BER, Q factor and Jitter Vs distance is given in the Table 2 for NRZ-RC modulation formats.

Table 2. NRZ-RC modulation formats

Distance in KM	BER	Q factor in dB	Jitter
100	9.76959x10^-11	16.280983	0.0222589
110	2.22988x10^-9	15.541077	0.0210096
120	6.87678x10^-8	14.438290	0.0209006

The calculated BER, Q factor and Jitter Vs distance is given in the Table 3 for RZ-R modulation formats.

Table 3. RZ-R modulation formats

Distance in KM	BER	Q factor in dB	Jitter
100	7.06613x10^-14	17.383271	0.00666308
110	6.15018x10^-9	15.248837	0.00201066
120	1.1117x10^-6	13.511832	0.0220722

The calculated BER, Q factor and Jitter Vs distance is given in the Table 4 for RZ-RC modulation formats.

Table 4. RZ-R modulation formats

Distance in KM	BER	Q factor in dB	Jitter
100	1.8818x10^-16	18.323260	0.0086519
110	5.5424x10^-13	16.995250	0.0159998
120	4.36455x10^-8	14.708237	0.021085

Further these calculation of various parameters showed that the performance of proposed DWDM system with RZ-RC modulation format is better than all other modulation formats. We can transmit data up to 120 KM with NRZ-R modulation format whereas it is limited to 110 KM in case of NRZ-R, NRZ-R and RZ-R modulation formats.

4. CONCLUSIONS

In this paper, DWDM system for three hundred eighty four transmitters is investigated. These transmitters can transmit data at the same fiber link. The sturdiness of NRZ-R, NRZ-RC, RZ-R and RZ-RC modulation formats at 10 Gbps with EDFA amplifier has been investigated. It has been observed that the most suitable data format for data transmission is RZ-RC which has the highest power levels with the minimum loss as compare to NRZ-RC, NRZ-R and RZ-R modulation formats. RZ-R modulation format also provides the better results than NRZ-RC and NRZ-R.

5. REFERENCES

[1] Gaurang R. Bhatt, Rajat Sharma, Uppu Karthik, and Bijoy K. Das, "Dispersion-Free SOI Interleaver for DWDM Applications", Journal of lightwave technology, vol. 30, no. 1, January 1, 2012.

[2] Peter Ossieur,Cleitus Antony, Aisling M. Clarke, Alan Naughton, Heinz-George Krimmel, Y. Chang, Colin Ford, Anna Borghesani, David G. Moodie, Alistair Poustie, Richard Wyatt, Bob Harmon, Ian Lealman, Graeme Maxwell, Dave Rogers, David W. Smith, Derek Nesset, Russell P. Davey, and Paul D. Townsend, "A 135-km 8192-Split Carrier Distributed DWDM-TDMA PON With 2 32 10 Gb/s Capacity", Journal of lightwave technology, vol. 29, no. 4, February 15, 2011.

[3] Diptish Dey, "Theory towards an all optical WDM slotted ring MAN with support for optical multicasting", Ph.D. Thesis, University of Twente, June 2003, available at http:/www.tup.utwente.nl/.

[4] Lucia Marazzi, Paola Parolari, Simone Seghizzi, and Mario Martinelli, "Raman-Generated Pump Impact on Optical Parametric Amplification" , IEEE Photonics Technology Letters, Vol. 16, No. 1, January 2010.

[5] Jun-Ichi Hashimoto, T. Takagi, T. Kato, G. Sasaki, M. Shigehara, K. Murashima, M. Shiozaki, and T. Iwashima, "Fiber-Bragg-Grating External Cavity Semiconductor Laser (FGL) Module for DWDM Transmission", Journal of lightwave technology, vol. 21, no. 9, September 2009.

[6] P. J. Urban, ,E. G. C. Pluk, M. M. de Laat, F. M. Huijskens, G. D. Khoe,A. M. J. Koonen, and H. de Waardt, "1.25-Gb/s Transmission Over an Access Network Link With Tunable OADM and a Reflective SOA" IEEE Photonics technology letters, vol. 21, no. 6, March 15, 2009, pp.380-382.

[7] Thomas Torounidis, Henrik Sunnerud, Per Olof Hedekvist, and Peter A. Andrekson, "Amplification of WDM Signals in Fiber-Based Optical Parametric Amplifiers", IEEE Photonics Technology Letters, VOL. 15, NO. 8, AUGUST 2003.

[8] R. Ramaswami, N.J. Sivarajan "Optical Networks, a practical perspective", second edition, Elsevier Science and Technology books, November 2001.

[9] G.P.Agrawal, Fiber-Optic Communication Systems. New York: Wiley, 1997.

[10] ITU Standard G.661 (07/07), "Definitions and test methods for the relevant generic parameters of optical amplifier devices and subsystems" (pre-published), International Telecommunication Union, 2007.

[11] T. Sabapathi, S. Sundaravadivelu, "Analysis of bottlenecks in DWDM fiber optic communication system", Optik, vol. 122, pg. 1453– 1457, 2011.

[12] S. Zafar Ali, M.K. Islamb, M. Zafrullah, "Effect of transmission fiber on dense wavelength division multiplexed (DWDM) chaos synchronization", Optik, pages – 1-5, 2012.