Comparative Performance Study in 32 Multiplexed Channels Optical Transmission in Bit Rates 10, 20, 30,40Gbps with NZDSF

Devendra Kr.Tripathi, H.K.Dixit, N.K.Shukla

Abstract- In this paper we have done comparative performance study for four different optical systems, each of thirty two multiplexed channels and spaced 100GHz. Multiplexed systems operating at 10, 20, 30 and40Gb/s/ch with non return-to-zero (NRZ) signal. The transmitted power is kept constant while the bit-rate and the length of the fiber are varied and the observations are based on the modeling and numerical simulation of optimum dispersion-managed transmission link .Performance study is done for variable fiber span length for NZDSF.It is observed that at low bit rate (10Gb/s/ch) per channel multiplexed optical system shows much better performance metrices (Q, BER, eye pattern) for variable fiber span. But with increase in per channel bit rate over10Gb/s/ch viz 20 Gb/s/ch, 30Gb/s/ch and 40Gb/s/ch transmission performance degrades on the increase of fiber length, it is much higher for 40Gb/s/ch multiplexed optical system as compared to other systems operating on 20, 30Gb/s/ch bit rate.

Key words: DWDM, OSNR, SPM, XPM

I. INTRODUCTION

In order utilize the available bandwidth, we can multiplex numerous channels on the same fiber and to increase system margins, higher transmitter power or lower fiber losses are required. Dense wavelength division multiplexing (DWDM) [1] is a fiber-optic transmission technique that employs light wavelengths to transmit multiple data signals.

DWDM can pack data channels closely together and accurate alignment allows more channels to fit within the same optical fiber. When the transmission capacity increases, the optical signal-to-noise ratio (OSNR) requirement increases, and hence, a high power optical signal needs to be applied to an optical fiber. This high power requirement for large OSNR leads to increased impairments arising from nonlinearities that exist in the optical fiber. Optical transmission networks based on wavelength division multiplexing (WDM) architecture will be dominating the all-optical data transportation with bit rates exceeding several terabit-per-seconds to serve the ever increasing current generation Internet Protocol (IP) networks[2, 3].

Requirement of higher capacity optical communication link is always looked in each stage of generation. The capacity of optical communication systems is growing exponentially in order to follow increasing demand of data traffic.

Explosive data traffic growth and higher optical capacity demand attracted researchers for designing new optical communication systems of higher transmission rates and using most of the existing available spectrum i.e. tries to increase spectrum efficiency of any desired system. Increasing the per-channel bit rate higher than 10 Gb/s is seen today as a way to achieve a very high spectral efficiency without the needing expensive dense wavelength-division multiplexing (DWDM) filter technology.

In single-channel transmission, the interaction between self-phase modulation (SPM) and group velocity dispersion (GVD) causes severe waveform distortion in high-power transmission. There are several techniques that can be used to overcome this nonlinear impairment. Dispersion management, which uses distributed in-line dispersion compensation using dispersion compensated fibers (DCFs) and fiber Bragg grating (FBG) instead of lumped compensation at the receiver or the transmitter, is quite effective in suppressing the SPM–GVD interaction [4, 5].Modulation format plays a significant role in defining the allowable fiber input power in long-haul transmission link. Conventionally, the nonreturn-to-zero (NRZ) modulation format has been used in long-haul transmission systems [6–8]. NRZ is used advantageous as it provides minimum optical bandwidth and minimum optical peak power per bit interval for a given average power, thus enabling higher spectral efficiency in the linear regime.

Previously there were analyses for the impact of PMD on XPM in terms of average bit error rate (BER) for a 4-channel intensity modulation-direct detection (IM-DD) WDM system at a bit rate of 10Gb/s per channel and the effects of PMD and XPM only for a 4-channel WDM system interms of eye diagram[9]. According to our knowledge the influence of PMD on XPM in terms of BER is only reported in [10] for a pump–probe optical transmission system. But at high bit rates, modulation format and channel power for modern long-haul fiber-optic transmission systems still remain the critical issue in debate for optimum system design. The subject of this work is to explore the SPM and XPM limited transmission distance using NZDSF with different bit rates in 10,20,30,40 Gb/s optical communication systems based on numerical simulations and modeling. So that we can analyze for optical transmissions suitability at different bit rates and its practical use.

Manuscript Received October 27, 2011.

Devendra Kr.Tripathi, J.k.I.T, University of Allahabad, Allahabad, India, 09839557481, (e-mail: dekt@rediffmaill.com).

Hemant Kr.Dixit, J.k.I.T, University of Allahabad, Allahabad, India , (e-mail: hkdixit@gmail.com).

Narendra Kr.Shukla, J.k.I.T, University of Allahabad, Allahabad, India , (e-mail: nksjkiapt@gmail.com).

II. THEORY

Fiber transmission is more challenging at higher bit rate than at 10Gbit/s. At high bit rate dispersion induces broadening of short pulses propagating in the fiber causes cross talk between adjacent time slots leading to errors when the communication distance increases beyond the dispersion length of the fiber. Actually at very high bit rate transmission fiber non linearity's creates great problem that limits the length of transmission. As chromatic dispersion is high at 1550 nm so extended developments of new fibers like dispersion shifted fiber which is designed to have zero dispersion and reduced pulse spreading due to chromatic dispersion in 1550nm band. Optical loss or attenuation and chromatic dispersion are linear degrading effects; SPM (self-phase modulation), XPM (cross-phase modulation), FWM (four-wave mixing), SRS (stimulated Raman scattering) and SBS (stimulated Brillion scattering) are nonlinear degrading effects. Fiber nonlinearities can be suppressed to an average level of chromatic dispersion with use of dispersion managed technique. In this dispersion managed fibers are arranged so that positive dispersion section and negative section both types can be accommodated within a single cable. Hence the average dispersion is zero. Different optical transmission performance metrics may be listed in compact form as:

Q-factor:

Q-factor measures the quality of an analog transmission signal in terms of its signal-to-noise ratio (SNR).As such, it takes into account physical impairments to the signal viz. noise, chromatic dispersion and any polarization or non-linear effects which can degrade the signal and ultimately cause bit errors. In other words, the higher the value of Q factor the better the SNR and therefore the lower the probability of bit errors.

$$Q = \frac{\mu 1 - \mu 0}{\sigma 1 - \sigma 0} \text{.................................}(a)$$

BER:

The BER can be estimated from equation (a), and requires Q>6 for the BER of 10-9 This BER give the upper limit for the signal because some degradation occurs at the receiver end.

$$BER = \frac{1}{2} erfc(\frac{Q}{\sqrt{2}}) \text{.........................}(b)$$

Considering only samples at the optimum sampling instant, it is the difference between the minimum value of the samples decided as logical''1''and the maximum value of the samples decided as logical''0''.The unit of this measurement is equal to the unit of the electrical input signal.

III. SYSTEM MODEL MODIFICATION

Here Rsoft optsim TM software is used which give us same realization as physical realization of the system. The different simulation parameters used are 100Ghz spacing between different 32 multiplexed channels. System consists of three major sections as follows.

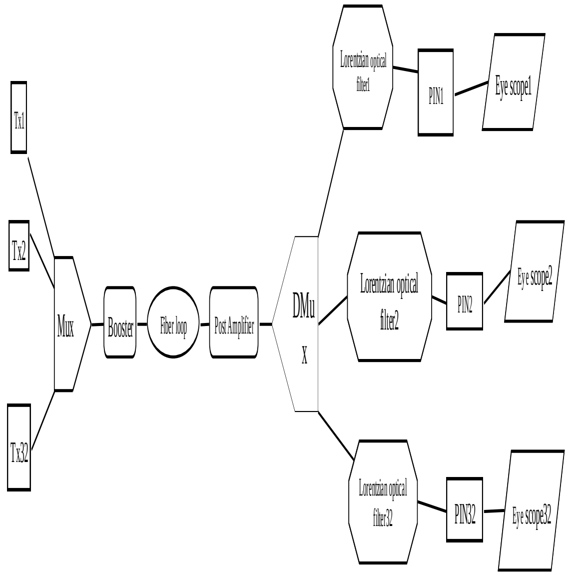

Figure3.1Simulation model for 32channel and 10,20,30,40 Gb/s/ch bit rate multiplexed system

a) Transmitter section

Thirty two channel transmitter sections whose output is multiplexed .The transmitter consists of a PRBS generator, which generates pseudo random bit sequences at the rate of 10, 20, 30,40Gbit/s/ch and this bit sequence is modulated. Booster having output power 5dBm and semiconductor optical amplifier used with 100mA.

b) Fiber section (Repeater loop)

Multiplexed optical signals are fed into the fiber repeater loop which consists of two short fibers of opposite dispersion values. The fiber model in OptSimTM takes into account the unidirectional signal flow. Fiber nonlinearities, PMD, birefringence are ON and Raman crosstalk is OFF.

c) Receiver section

At the output of the multi stage Lorentzian optical filter and detection is done by the PIN diode detectors. Each Lorentzian optical filter having -3dB bandwidth 30Ghz and each Bessel electrical filter having -3dB bandwidth as 20Ghz used. Detection is tested for four Chanel which are operating at receiver1, receiver8, receiver17, receiver24 receiver32and (whose output is applied to a visualization tool called Scope. It is an electrical oscilloscope with numerous data processing options, eye display and BER estimation features. If the eye opening is very wide and there is no crosstalk. Eye diagrams are used to effectively analyze the performance of an optical system. Eye diagrams clearly depict the data handling capacity of an optical transmission system. The more the eye is open, the more efficient the system. Performance degradation will directly affect the eye diagrams which in turn results in reduced eye opening and time jitter at the edge.

IV. RESULT AND DISCUSSION

Performance study has been done for 32channel multiplexed optical system operating at different bit rates that are 10, 20, 30 and 40Gbps. Comparing various results shown in figure (4.2) to figure (4.9) for different bit rates it is observed that 10Gb/s/ch system Q is highest for a length of 20km and at 260km fiber length Q and eye opening is also much better as compared to other bit rates systems. It is observed that at 260km Q is 13dB for 10Gb/s/ch optical system and for 20Gb/s/ch, 30Gb/s/ch Q is more than 10dB which is good for optical transmission but for 40Gb/s/ch it is observed that at 20km fiber span Q and eye openings are much better but as fiber span increases both Q and eye opening deteriorates .For 40Gb/s/ch optical system Q goes down below 10dB line for channels detected near around 130km of fiber span and finally Q goes down on the increase of fiber length and it touches 6.0200dB line for all channels detected. Hence it may be concluded on increasing fiber length and bit rates per channel for low bit rates (10Gb/s/ch) multiplexed 32channel optical system optical transmission parameters (Q, BER, eye opening) are much better, while on increasing per channel bit rates for 32 channel multiplexed optical transmission parameters (Q, eye opening and bit error rates) deteriorates largely, particularly with 40Gb/s/ch multiplexed optical system. Since various nonlinearities, signal attenuation crosstalk increases with the increase of fiber span. It can be seen in the figure that with the increase in the number of fiber spans the Q value decreases. Since 40Gb/s is 16 times more sensitive to dispersion as 10Gb/s, it requires at least 6 dB higher signal-to-noise ratio (SNR) at the receiver for the equivalent bit-error rate (BER), and the fiber itself now limits transmission at distances that were never a problem at lower rates. Also particularly 40Gb/s/ch optical transmission has shown verse since NRZ lacks of the necessary dispersion tolerance to accommodate for high bit rate.

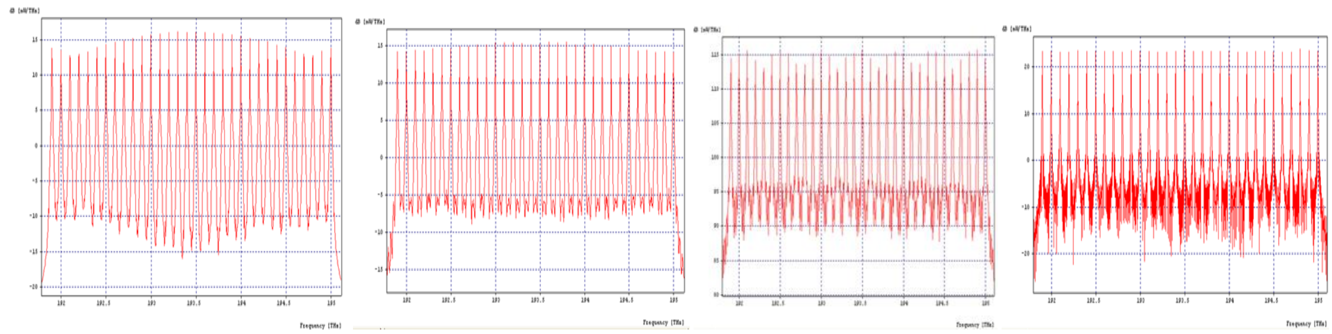

Figure4.1- Input power spectrum for 32 channel with 40,30,20,10 Gb/s/ch respectively

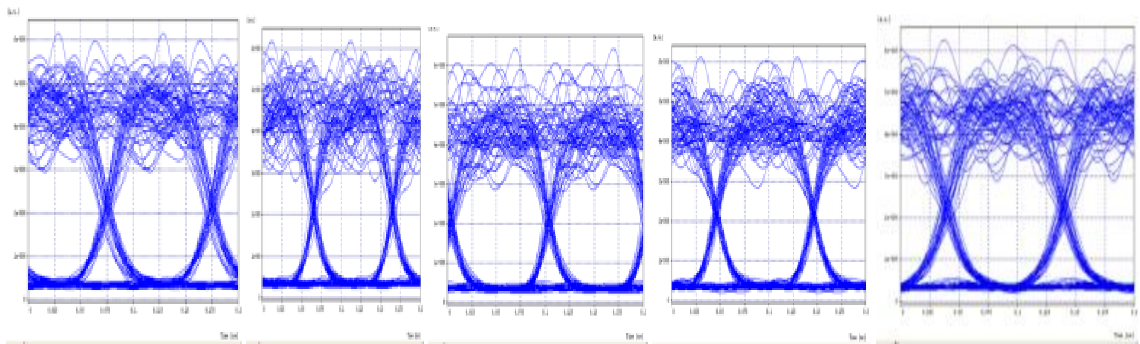

Figure4.2- At 200km eye pattern for (32x10Gb/s) ch1, 8,17,24,32

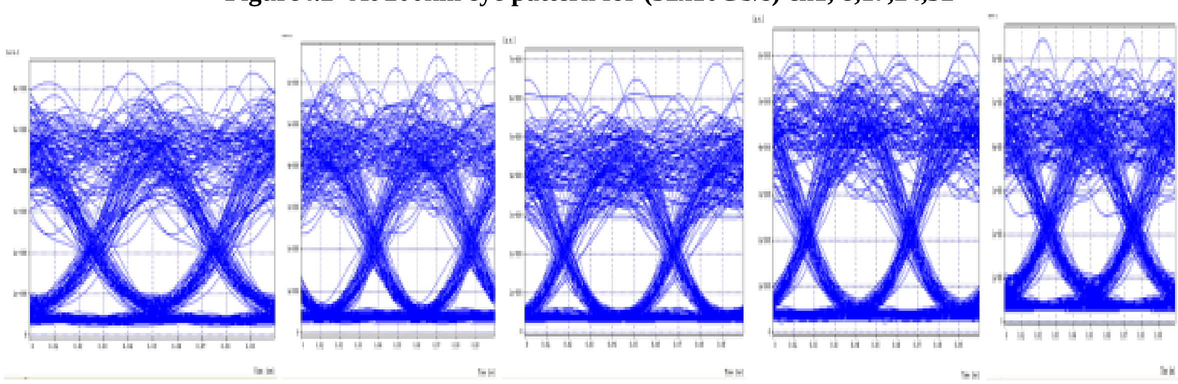

Figure4.3- At 200km eye pattern for (32x20Gb/s) ch1, 8,17,24,32

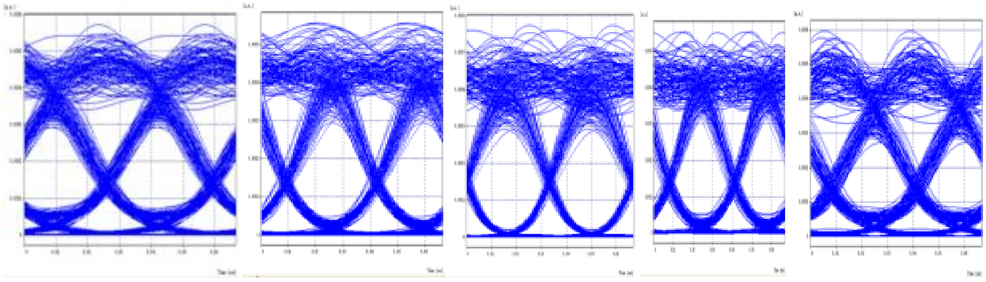

Figure4.4- At 200km eye pattern for (32x30Gb/s) ch1, 8,17,24,32

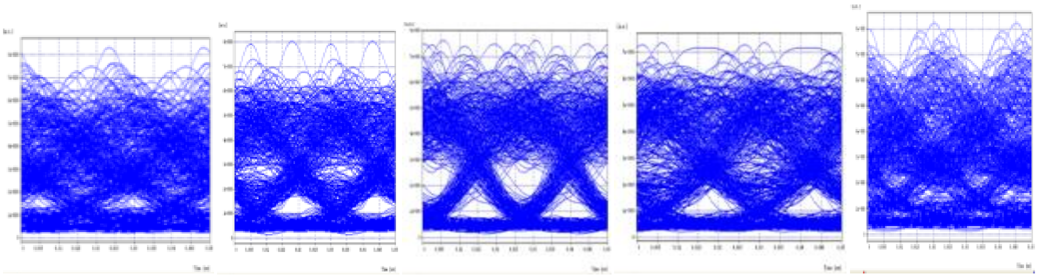

Figure4.5- At 200km eye pattern for (32x40Gb/s) ch1, 8,17,24,32

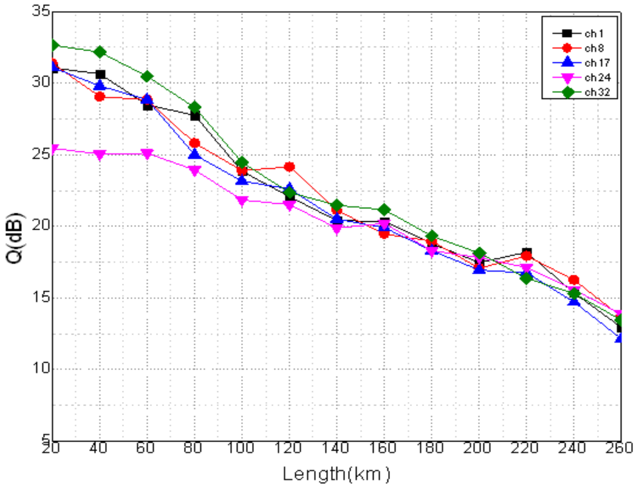

Figure 4.6.Q vs. length plot for (32x10Gb/s) system with NZDSF

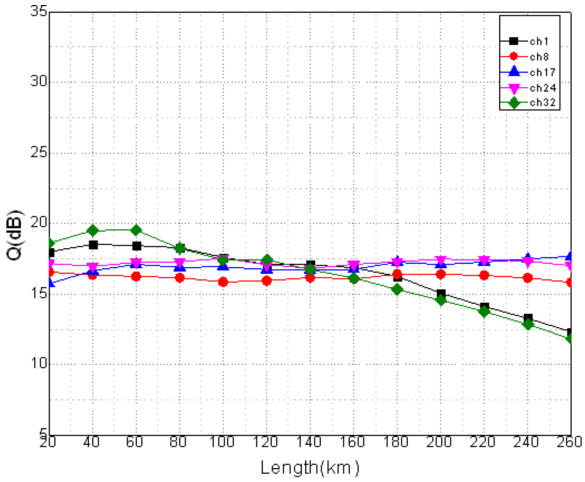

Figure 4.8.Q vs. length plot for (32x30Gb/s) system with NZDSF

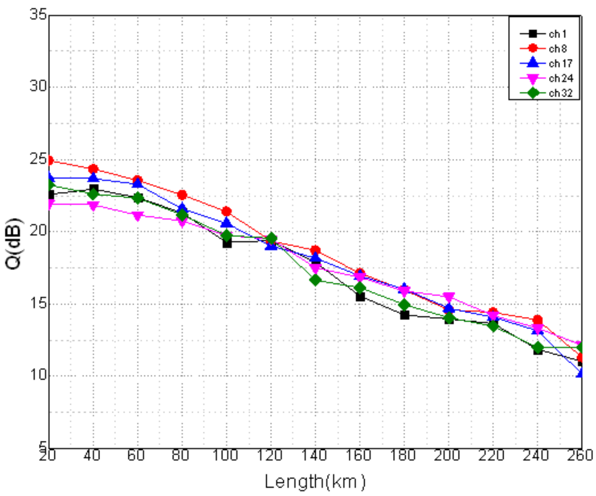

Figure 4.7.Q vs. length plot for (32x20Gb/s) system with NZDSF

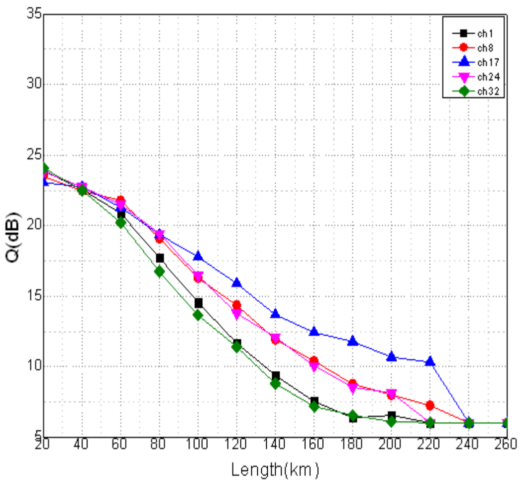

Figure 4.9.Q vs. length plot for (32x40Gb/s) system with NZDSF

V. CONCLUSIONS

Comparative multiplexed optical performance study for 32channel system operating at 10, 20, 30,40Gb/s/ch has been carried out for NZDSF. Observing various results it is clear that with increase of per channel bit rate nonlinearities limits the fiber transmission length, while with lower bit rate system performance parameters are very attractive, also for 40Gb/s/ch optical transmission NRZ lacks of the necessary dispersion tolerance to accommodate **.**

REFERENCES

1. C. A. Brackett, "Dense wavelength division multiplexing networks: Principles and applications," IEEE J. Selected Areas Communications, vol. 8, pp. 948–964, August 1990.
2. Meccozi, A.," Wiesenfeld, J. M.: "The roles of semiconductor optical amplifiers in optical networks". Opt. Photon., 3, 2001.
3. Li, G. L.; Yu, P. K. L., "Optical Intensity Modulators for Digital and Analog Applications". J. Lightwave Technol. 21 ,2003.
4. Govind P. Agrawal, "Fiber-Optic Communication Systems", third ed, Academic Press, New York, 2002.
5. Govind P. Agrawal, "Nonlinear Fiber Optics", third ed, Academic Press, New York, 2001.
6. D. Breuer, K. Petermann, "Comparison of NRZ- and RZ- modulation format for 40-Gb/s TDM standard-fiber systems", IEEE Photon. Technol. Lett. ,pp.398,9 ,1997.
7. M.I. Hayee, A.E. Willner, "NRZ versus RZ in 10-40-Gb/s dispersion managed WDM transmission systems", IEEE Photon. Technol. Lett. Photon. Technol. Lett., pp. 991–993, 11 1999.
8. G. Bosco, A. Carena, V. Curri, Member, R. Gaudino, P. Poggiolini, "On the use of NRZ, RZ, and CSRZ modulation at 40 Gb/s with narrow DWDM channel spacing", IEEE J. Lightwave Technol.,pp , 1694–1704, 20 , 9,2002.
9. Md. SaifulIslam, S. P Majumder "Effects of polarization mode dispersion on cross-phase modulation in a WDM optical transmission system", Elsiever OptiK, pp., 24-28,122, 2011.
10. M.S. Islam, S.P.Majumder, "Influence of polarization mode dispersion on the effect of cross-phase modulation in intensity modulation – direct detection WDM transmission system," in: Proceedings of International Conference on Computer and Communication Engineering (ICCCE2008), vol. 1, pp. 247–251, 2008

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication