International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)
Volume 4, Issue 3, March 2015

Performance Comparison of Pre-, Post- and Symmetrical-Dispersion Compensation Techniques using DCF on 40Gbps WDM System

Manpreet Kaur, Himali Sarangal

***Abstract*— Various factors like chromatic dispersion, polarization mode dispersion, non-linear effects, second order and third order dispersion impose limit on the performance of all the optical networks. In this paper, WDM optical system at 40 Gb/s has been investigated for the three dispersion compensation techniques (pre, post and symmetrical) using dispersion compensating fibers (DCF). The performance has been compared on the basic of different parameters at the receiving end. Optisystem 7.0 is used for designing and simulation of the proposed system. It is observed that the symmetrical-compensation scheme performs better than pre-, post-compensation schemes for 8 x 40 Gb/s WDM system.**

***Index Terms*—Dispersion, WDM (wavelength division multiplexing), EDFA, DCF, BER.**

I. Introduction

In order to increase the information carrying capacity of an optical fiber communication system, wavelength division multiplexing (WDM) is one of the most efficient techniques used in optical communication systems. The information carrying capacity in WDM can be further enhanced by increasing either the per-channel data rates or the number of multiplexed channels. The transmission in WDM optical networks is affected by attenuation, chromatic dispersion, polarization mode dispersion and the fiber non-linear effects at high bit rate and power level. In order to compensate for the attenuation losses optical amplifiers (EDFA, SOA, Raman amplifier) are used. Since all the channels need to be amplified simultaneously so optical amplifiers like Er-doped fiber amplifiers (EDFAs) are mostly used in optical fiber communication networks. EDFAs operate in 1550 nm wavelength window. [1], [2]

In WDM optical networks, the dispersion compensation is a key issue. To compensate dispersion in WDM systems, various methods can be used, which are microchip compensation, mid span spectral inversion, optical phase conjugation, initial pre chip, fiber bragg gratings (FBG). [3]

Considering all these dispersion compensation methods, the dispersion compensating fibers (DCFs) has been used in this paper to reduce the overall dispersion of the optical fiber link. The dispersion compensating fiber can be connected in three configuration, pre, post and symmetrical.

Gurinder Singh, Ameeta Seehra and Sukhbir Singh [4] investigated the WDM system at 40 Gbps using dispersion compensating fibers over 50 km of single mode fiber and 10 km of DCF with RZ super Gaussian pulse. The number of spans was taken to be 4, i.e. the total length of the link is 240 km. In their investigation, the performance of pre, post and symmetrical dispersion compensation techniques is compared for the different WDM systems.

In this paper, we have extended the work reported in [4]. We investigated the WDM system at 40 Gbps using DCF over 120 km of optical fiber and 24 km of DCF. The number of spans is taken to be 2. So the total length of the link is 288 km.

The rest of the paper is organized as followed; in section II, the dispersion compensating fibers are discussed. Simulation methodology is described in section III. In section IV, the results and discussion is presented and section V concludes the paper.

II. Dispersion compensating fibers (DCFs)

The idea of using dispersion compensating fibers for dispersion compensation was proposed in 1980s. As the components of DCF are more stable, not easily affected by temperature, wide bandwidth, DCF has become the most suitable method for dispersion compensation. It is currently used as the standard solution for dispersion compensation in long-haul WDM optical transmission links. The use of DCF is an efficient way to reduce the overall dispersion in WDM network as they have higher negative dispersion coefficient and can be connected to the transmission fiber having the positive dispersion coefficient i.e. the overall dispersion of the link becomes zero.

Dispersion compensation is done by three different schemes depending upon the position of DCF:

i. Pre-compensation
ii. Post-compensation
iii. Symmetrical-compensation

In pre-compensation scheme, the DCF is placed before the standard single mode fiber (SSMF) to compensate the positive dispersion in SSMF.

In post-compensation, the DCF is placed after the SSMF to compensate the positive dispersion in SSMF.

In symmetrical-compensation, both the schemes (pre-, post-compensation) are used i.e. DCF is placed before as well as after the SSMF to achieve the dispersion

Manpreet Kaur (M.Tech student), *Department of Electronics and Communication Engineering, GNDU Regional campus Jalandhar, Punjab, India.*
Himali Sarangal (Assistant. Professor), *Department of Electronics and Communication Engineering, GNDU Regional campus Jalandhar, Punjab, India.*

ISSN: 2278 – 909X

compensation. [4] - [7]

III. SIMULATION SETUP

The eight channel WDM optical network is designed using the Optisystem 7.0 simulator software. We have simulated the three DCF compensation schemes (pre-, post- and symmetrical-compensation) at 40 Gbps. We use the parameters in Table 1 for the simulations.

In the simulations, the transmitter section consists of data source, which produces a pseudo random sequence of bits at 40 Gbps. NRZ pulse generator converts the binary data into electrical pulses that modulates the laser signal through the Mach-Zehnder (M-Z) modulator. The transmitter section block diagram is shown in "Fig. 1".

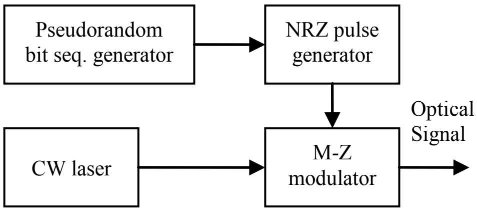


Fig. 1 Transmitter section [4]

There are eight laser sources generating optical signals of different wavelengths, the channel spacing used is 200 GHz, with 1 dbm output power.

The multiplexer combines the eight input channels and transmit over optical fiber channel. The transmission channel consists of SSMF of length 120 km and DCF of length 24 km. The number of spans is taken to be 2 in pre- and post-compensation schemes i.e. the total link length is 288 km. In symmetrical-compensation scheme only single span is used. 2 DCFs each of length 24 km and 2 SSMFs of 120 km each are used, so that the total length of the link is same 288 km in all the three compensation schemes. Er-doped fiber amplifiers (EDFA) are used between the links in order to amplify the signals.

At the receiver side, the 1:8 demultiplexer is used to splits the signals to 8different channels. The output of the demultiplexer is given to PIN photodetector and then passes through low pass electrical Bessel filter and 3R regenerator. The receiver side block diagram is shown in "Fig. 2".

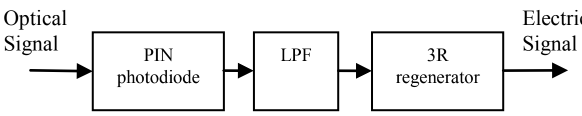


Fig. 2

Receiver section [4]

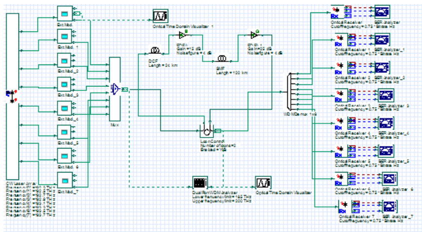
Table 1. Simulation parameters

Parameters	Value
Bit rate	40 Gbps
Sequence length	64
Samples per bit	256
Central frequency of first channel	192.3 THz
Channel spacing	200 GHz
Capacity	8x40 Gbps

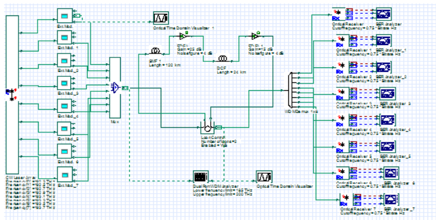
Table 2. Fiber parameters

	SMF	DCF
Length (km)	120	24
Attenuation (db/km)	0.2	0.6
Dispersion (ps/nm/km)	17	-80
Dispersion slop (ps/nm^2/km)	0.08	0.3
Differential group delay (ps/km)	0.5	0.5

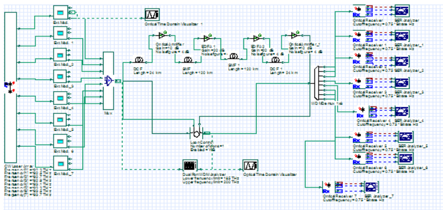
The simulation setups of three dispersion schemes are shown in Fig.3.



(a) Pre-compensation



(b) Post-compensation

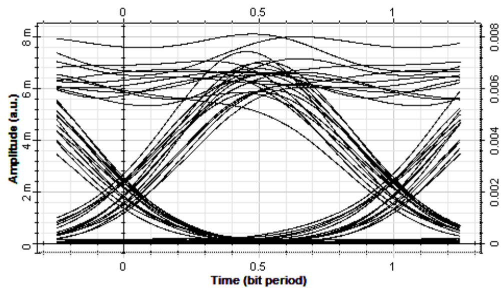


(c) Symmetrical-compensation

Fig. 3 Simulation setup of three dispersion compensation schemes

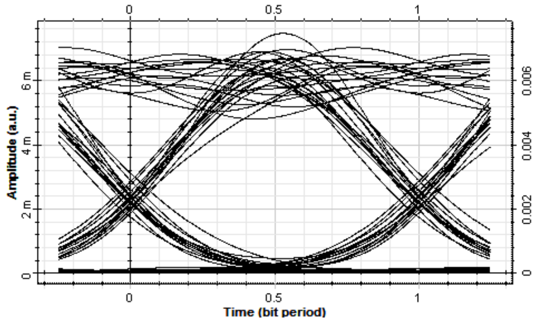
IV. RESULTS AND DISCUSSION

The three dispersion compensation schemes have been analyzed at 40 Gbps for WDM optical network in terms of bit error rate (BER), Q-factor and eye height. The eye diagrams for the pre-, post- and symmetrical-compensation are shown in "Fig. 4". The graphs for BER, Q-factor and eye height for all the users with the three schemes are shown in "Fig.4" and the values for the first, second and last user are tabulated into Table 3 and are compared.

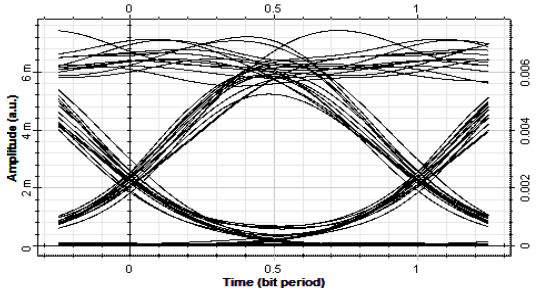


(a)

ISSN: 2278 – 909X

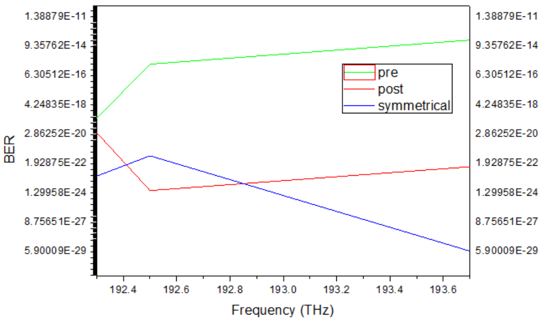


(b)

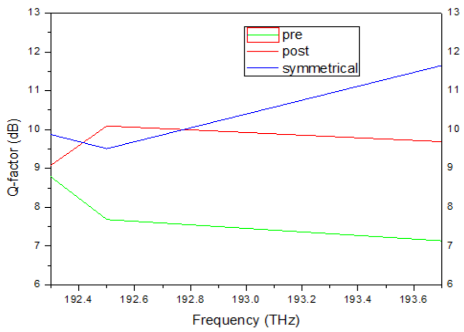


(c)

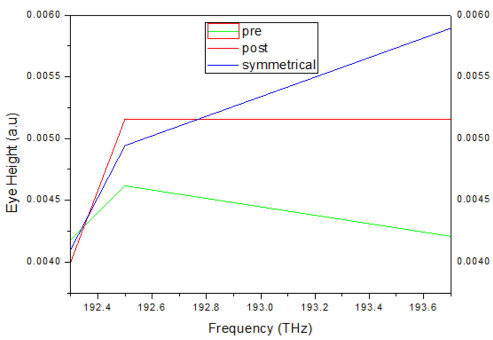
Fig. 3 Eye diagrams of (a) pre-compensation (b) post-compensation and (c) symmetrical-compensation at first channel (192.3 THz)



(a) BER for 8 users at different freq.



(a) Q-factor for 8 users at different freq.



(a) Eye height for 8 users at different freq.

Fig.4 Comparison of three compensation schemes

Table 3. Comparison of three schemes

At 192.3 THz

	Pre compensation	Post compensation	Symmetrical compensation
Q-factor (db)	8.78627	9.08408	9.87489
BER	4.32497e-019	3.91871e-020	2.33614e-023
Eye height	0.00418286	0.00400196	0.00410305
At 192.5 THz			
Q-factor (db)	7.68547	10.0952	9.50989
BER	4.55109e-015	2.01069e-024	7.513e-022
Eye height	0.00461699	0.00515891	0.00494292
At 193.7 THz			
Q-factor (db)	7.13798	9.69011	11.6514
BER	2.72476e-013	1.16402e-022	6.62201e-029
Eye height	0.00420787	0.00515493	0.00589319

V. CONCLUSION

In this paper, we have analyzed the 8 channel WDM system at 40 Gbps for different dispersion compensation schemes using DCF. The three dispersion compensation schemes using DCF (pre-, post- and symmetrical-compensation) are compared in terms of BER, Q-factor and eye height. We observed that the symmetrical-compensation scheme performs better than the pre- and post-compensation schemes.

ACKNOWLEDGMENT

The authors would like to acknowledge the Guru Nanak Dev University (GNDU) for providing the Optisystem software.

REFERENCES

[1] R.S. Kaler, "Simulation of 16 x 10 Db/s WDM system based on optical amplifiers at different transmission distance and dispersion," *Optik* 123, 1654-1658, 2012.

[2] M.I. Hayee, A.E. Willner, Senior Member, "Pre and post-compensation of dispersion and linearities in 10-Gb/s WDM, *IEEE Photon. Technology, Lett*. 9 (9), 1999.

[3] R.J. Nuyts, Y.K. Park, P. Gallion, Dispersion equalization of a 10 Gb/s repeatered transmission system using dispersion compensating fibers, *J. Lightwave Tech nol.* 15 (1), 31–42, 1997.

[4] Gurinder Singh, Ameeta Seehra and Sukhbir Singh, "Investigations on order and width of RZ super Gaussian pulse in different WDM systems at 40 Gb/s using dispersion compensating fibers," *Optik 125*, 4270-4273, 2014.

[5] R.S. Kaler, A.K. Sharma, T.S. Kamal, "Comparison of pre-, post- and symmetrical- dispersion compensation schemes for 10 Gb/s NRZ links using standard and dispersion compensated fibers," *Optics. Communication,* 209, 107–123, 2002.

[6] Bo-Ning HU, Wang Jing, Wang Wei, Rui-Mei Zhao, "Analysis on Dispersion Compensation with DCF based on Optisystem," *IEEE 2nd International Conference on Industrial and Information Systems*, 40-43, 2010.

[7] Manpreet Kaur, Himali Sarangal, "Analysis on Dispersion Compensation with Dispersion Compensation Fiber (DCF)," *SSRG International Journal of Electronics and Communication Engineering (SSRG-IJECE),* ISSN: 2348 – 8549 – vol. 2 issue 2, 56-59, Feb 2015.

ISSN: 2278 – 909X