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PERFORMANCE ANALYSIS OF DISPERSION REPARATION USING DISPERSION COMPENSATION FIBER AT 100 GB/S FOR 120KM USING SINGLE MODE FIBER

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ABSTRACT

Since the data traffic is increasing day by day so there is a need of high capacity long distance optical links.As the data transmission increases over a long distance,signal gets deteriorated.This is because of the pulse widening known as dispersion and it should be compensated for better results.Different compensation techniques are available like FBG, EDC and DCF. Hence, in this paper we have used DCF as dispersion compensator at a bit rate of 100Gbps over a distance of 120km.ThreeDCF schemes i.e. pre,post and symmetric are proposed and investigated at different input power levels (1-10dBm).The results of these three schemes are then compared in terms of quality factor and bit error rate.Post compensation scheme of DCF exhibits low bit error rate and high quality factor.Thus, making it a best technique for dispersion compensation using DCF..

KEYWORDS: Dispersion; Optisystem; Q-factor; Bit error rate (BER); Chromatic Dispersion (CD); Inter Symbol Interference; PMD (Polarization mode dispersion).

I. INTRODUCTION

In the past years there is a brisk growth of internet users around the world.As a result need for high data transmission rates and high bandwidth increases, which is further becoming a tough challenge for service providers. So in order to fulfill these demands optical fiber is becoming more beneficial medium and playing an important role in the transmission of signals with high bandwidth and minimum losses as compared to other earlier used mediums like twisted pair cable, copper cables etc.So it is necessary to explore the transmission characteristics of optical fiber.

In optical fiber communication system,optical signals are transmitted through fiber overa long distance. A signal is made up of different wavelengths and these different wavelength signals have different propagation time because fiber core has different refractive indexes for different wavelengths [1]. The concept of WDM has increased the applications of optical fiber to fulfill the requirements of high data transmission rate with high bandwidth and high channel capacity [2].In WDM all the signals are multiplexed and then send over the fiber. While travelling inside the optical fiber, these signals deteriorate.This deterioration is caused by dispersion and other fiber linearity [3].EDFA is a major change, due to which losses can be avoided to a certain extent, but dispersion is a factor that should be considered during long distance transmission.A fiber loss causes link distance to be limited in optical communication system.Using EDFA in 1550nm wavelength window, increases link distance thus limiting bit error and propagation delay [4].

The major goal of optical communication system is to achieve long distance transmission with less bit error rate and maximum quality factor.Toachieve this,dispersion should be compensated. Out of different types of dispersion, chromatic dispersion is the most prominent, and can becompensated using different compensation techniques like Dispersion Compensating Fiber(DCF), Fiber Bragg Grating(FBG) and ElectronicEqualizers etc.

A. Dispersion

At the point when a light signal goes inside the optical fiber it comprises of various wavelengths and goes at various speeds. These speeds comes to at yield at various time intervals which makes pulse to be widened. This pulse widening is known as dispersion. This dispersion causes distortion for both analog and digital signal transmission.

Chromatic dispersion is more presiding than other dispersions. So, chromatic dispersion D in ps/nm/km [5]can be defined as given below in equation (1):

$$D = \frac{d}{d\lambda}\left(\frac{1}{v_g}\right) = \frac{d^2\beta}{d\lambda d\omega} \approx \frac{-2\pi c}{\lambda^2}\beta_2 \quad (1)$$

Where,
ω is angular frequency
λ is operating frequency
v_g is group velocity
c is the velocity of light
β_m is the order of propagation which is given as below

$$\beta_m = \left(\frac{d^m\beta}{d\omega^m}\right)_{\omega=\omega_0} \text{ Wherem= } (0,1,2\ldots\ldots\ldots\ldots..)$$

Since chromatic dispersion depends upon wavelength so it can be defined as chromatic dispersion slope as given below in equation (2):

$$\frac{dD}{d\lambda} = \frac{2\pi c}{\lambda^3}\left(2\beta_2 - \frac{2\pi c}{\lambda}\beta_3\right) \quad (2)$$

Because of dispersion, pulses at the yield overlaps with its neighbor pulses which causes intersymbol interference. This ISI limits data transfer capacity and expanded BER with decline in Quality Factor. Polarization mode dispersion is another signal degrading element. Single mode fiber conveys its transverse mode with two distinct polarizations states and a little mutilation in the fiber can change the propagation speeds of these two modes. This is known as birefringence and causes pulse broadening.

B. Dispersion Compensation Techniques

To improve the overall performance of the system, several dispersion compensation techniques are there. Among all those techniques, some techniques are most commonly used and they are classified as DCF(Dispersion Compensating Fibers),FBG(Fiber Bragg Grating) and EDC(Electronic Dispersion Compensation).

The idea of utilizing DCF was first proposed in 1980.Since the elements of DCF are more stable and not effectively influenced by the temperature so it gives wide bandwidth[6].DCF is the best technique to manage compensation and upgrade already installed fiber links. In SMF second and third order positive dispersion is available while DCF have negative dispersion value. So by inserting DCF, normal dispersion winds up plainly zero as appeared in Fig-1.In request to get a high estimation of negative dispersion, doping of core of compensating fiber ought to be as high when contrasted with other conventional fibers [7, 8].Earlier Dispersion Shifted Fibers (DSF) are utilized to compensate dispersion at 1.55μm wavelength, for example, four wave mixing and cross phase mixing are high at this wavelength. That is the reason DCF is utilized [9,10,11].Given equation (3) satisfies the condition of dispersion compensation.

$$D_1L_1 + D_2L_2 = 0 \quad (3)$$

Where
$D_1 D_2$ are the dispersion coefficients of SMF and (DCF), respectively
$L_1\, L_2$ are the lengths of SMF and DCF, respectively

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Figure1:Dispersion Compensating Fiber

The remaining part of the paper is organized as followed:Section IIincludes the simulation setup. Section III consists of simulation results in the form of eye diagrams and comparison tableand finally Section IV includes the conclusion of the paper.

II. SIMULATION SETUP

A. Proposed System

As we know that if we have to transmit a signal to a long distance, chromatic dispersion is the major problem which degrades the quality of the output signal. Hence compensation is must. So here in this proposed model, we are using a bit rate of 100 Gb/s to transmit a non return to zero signalover a distance of 120 km by using single mode fiber.Here we are using pseudo random bit generator for random bit sequence and Mach-Zehnder modulator along with the Dispersion compensating fiber (DCF). On the basis of the position, DCF can be used in three schemes i.e.Pre compensation, Post compensation and Symmetricalcompensation.

i) Pre Compensation DCF

This compensation method consists of DCF,SMF and EDFA.DCF having negative dispersion is placed before SMF to compensate positive dispersion of SMF.EDFA after DCF is used to provide periodic amplification which is shown in Fig-2:

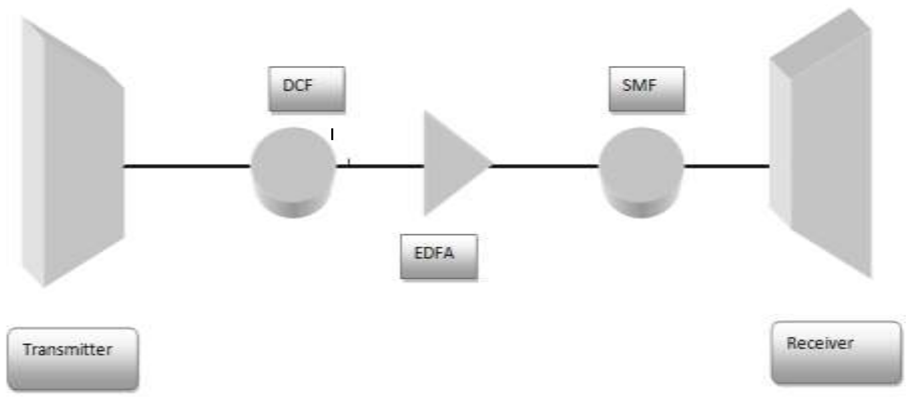

Figure 2: Pre Compensation DCF

ii) Post Compensation DCF

In order to reduce pulse broadening and distortion at output another compensation known as post compensation is used where SMF is placed before DCF shown below in Fig-3:

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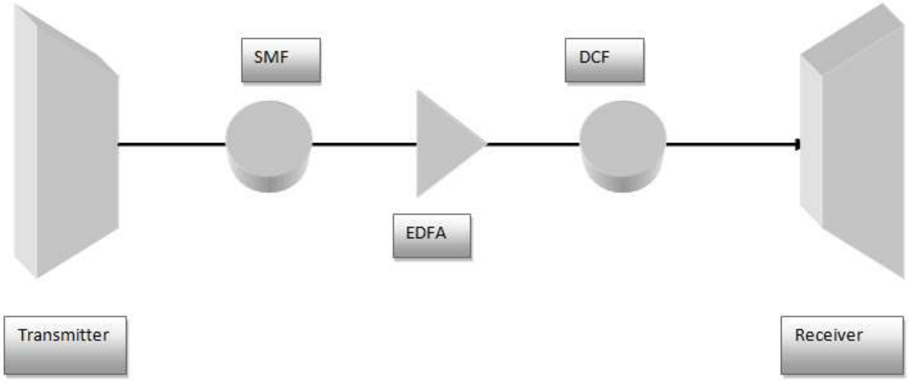

Figure 3: Post Compensation DCF

iii) Symmetrical Compensation DCF

In this compensation scheme, DCF having negative dispersion is placed before and afterSMF to compensate positive dispersion of single mode fiber as shown below in Fig-4:

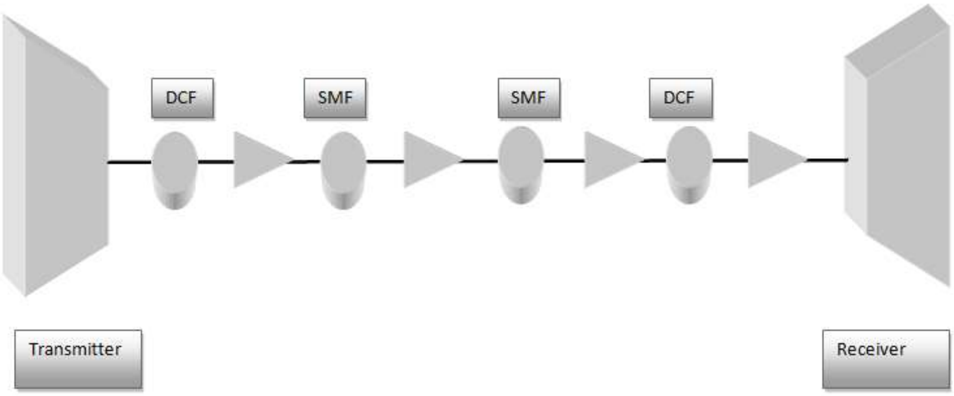

Figure 4: Symmetrical Compensation DCF

B. Simulation Modal

In order to achieve high capacity data transmission rate at long distances,optical fiber should be updated in such a way to compensate for the losses and deterioration caused by dispersion.For this, different compensation techniques are used like DCF, FBG etc. Here we are using DCF.It is executed in three schemes i.e. pre,post and symmetric.Optisystem 7.0 is used for the simulation of above mentioned model. Refinement in dispersion with the help of DCF in different configuration is showed in Fig. 5, 6 and 7.

The simulation setup consists of transmitter, channel and receiver.Initially on the transmitter side, pseudo random bit sequence generator is utilized as a data source to generate bits for the transmission in the form of zeros and ones at a rate of 100 Gb/s.This binary data is changed over into the type of electrical pulses by using NRZ pulse generator.To transmit signal over large distances,signal need to be modulated.Therefore a continuous wave laser is used to generate the high frequency carrier signal of frequency193.1THz. Signal with carrier frequency is modulated using Mach-Zehnder modulator.During the propagation of signal over optical fiber we have used DCF as a dispersion compensator. The transmission channel has been consisted of SMF and DCF.For transmission of signals DCF of 24 km is brought with SMF of 120km.Due to the transmission through DCF and SMF, signal suffers lots of attenuation which causes signal to be weakened. Subsequently, an amplifier i.e. EDFA having gain of 20dB and constant noise figure equivalent to 2 is used after DCF and SMF.

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Table 1:Simulation Parameters

Sr. No.	Parameter	Value
1	Bit Rate(Gbps)	100
2	Sample Rate(THz)	6.4
3	Frequency(THz)	193.1
4	Power(mW)	1
5	Extinction Ratio	30
6	Gain (dB)	20
7	Noise(dB)	2

Table 2: FiberParameters

Sr. No.	Parameter	Value
1	Length of Fiber(Km)	120
2	Reference wavelength(nm)	1550
3	Length of DCF(km)	24
4	Attenuation(db/km)	0.3
5	Differential slope (ps/$nm2/km$)	0.21
6	Dispersion(ps/nm/km)	-80

At the receiving end the optical signal is changed back into electrical signal by Photo detector i.e. Pin diode. A low pass filter is utilized to isolate carrier from the signal. Finally a BER analyzer is used to analyze the signal. At the receiving ends, the outcomes are compared in terms of Eye diagram, Q factor, bit error rate and eye height for different DCF configurations. For simulation and fiber, distinctive parameters have been used, mentioned in Table-1 and 2.

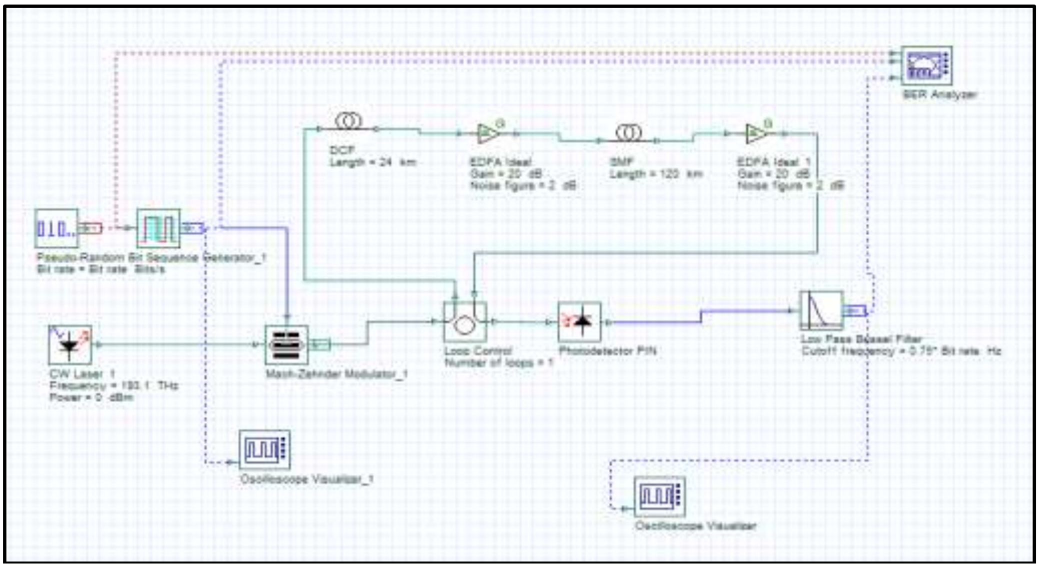

Figure5: Pre compensation using DCF simulation mode

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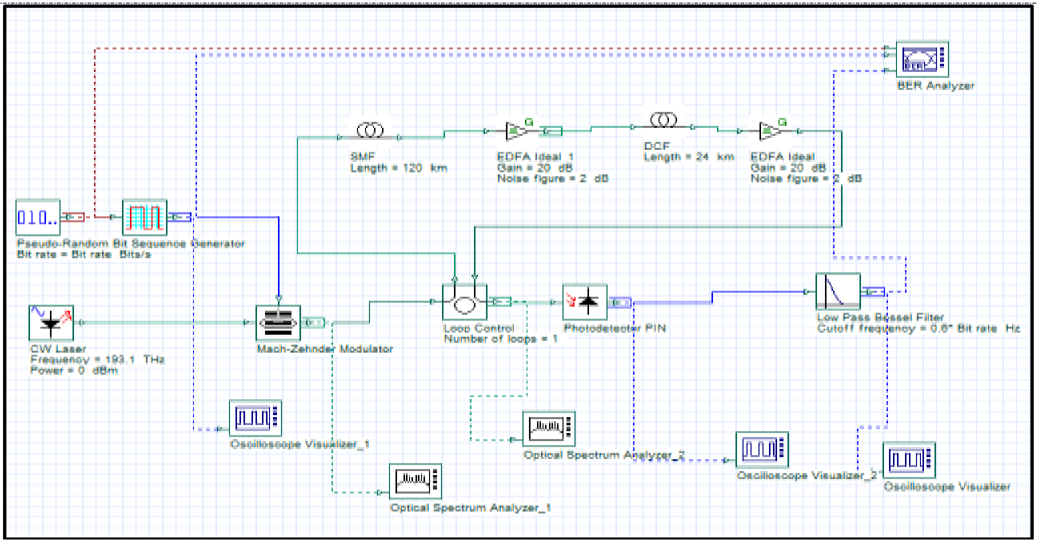

Figure6: Post compensation using DCF simulation models

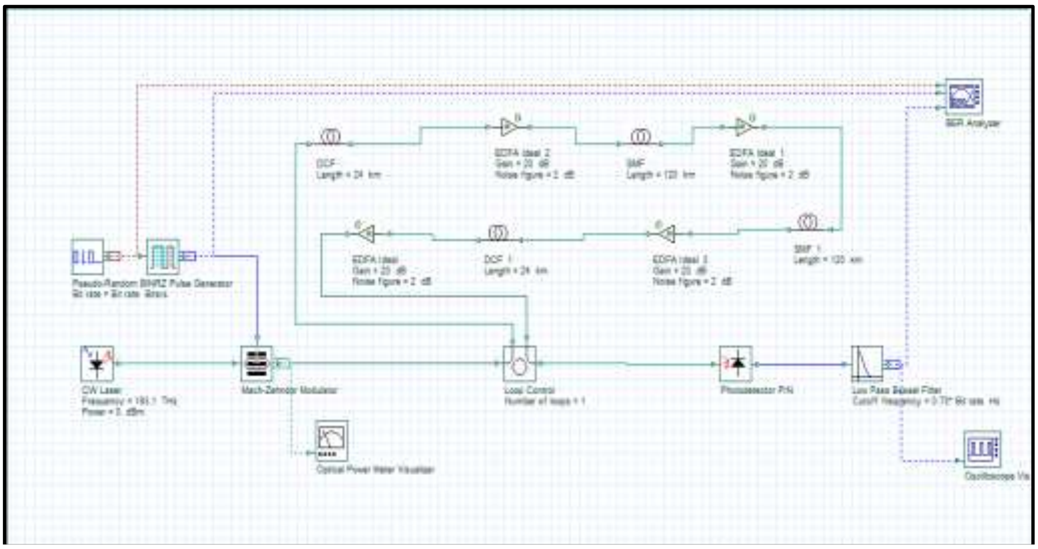

Figure7: Symmetrical compensation using DCF simulation model

III. SIMULATION RESULT

Compensation by using DCF at a rate of 100Gbps for a distance of SMF of 120 km has been analyzed in terms of quality factor, bit error rate,eye height and threshold value for input powers ranging from 1-10dBm. The eye diagram for different schemes of dispersion compensating fiber(DCF) i.e. pre compensation, post compensation and symmetrical compensation are shown in Fig- 8, 9 and 10 respectively. The BER, Quality factor, Eye height and Threshold for three distinct schemes are tabulated in the Table-4, 5 and 6, respectively. Pre compensation technique of DCF is having greatest quality factor and least bit error rate as compared to others.

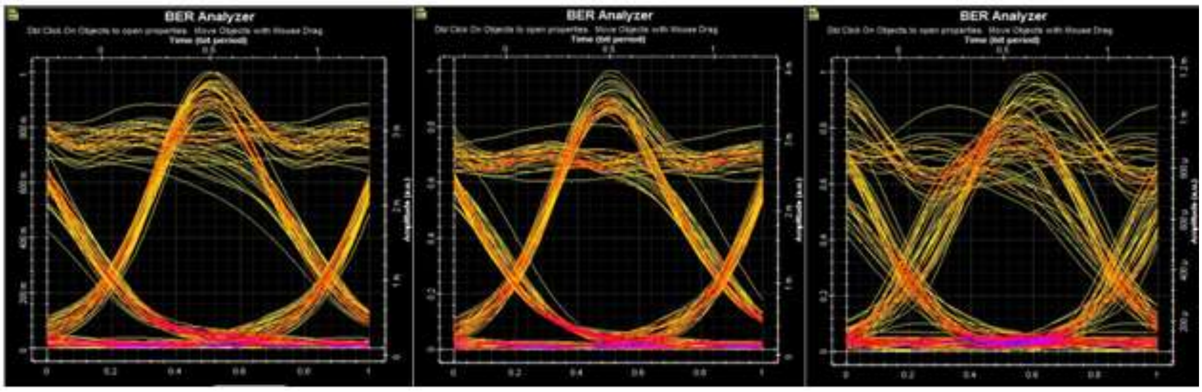

Figure 8:Pre schemeat 10dBFigure 9: Post scheme at 10dBFigure 10. Symm.schemeat 10dB

Table 4: Results for Pre Compensation of DCF at inputs from 1dbm to 10dbm

Iterations	Q factor	BER	Eye Height	Power (dbm)
1	6.28	1.52E-10	0.000174	-42.3
2	6.95783	1.65E-12	0.000239155	-40.511
3	7.63629	1.08E-14	0.000321066	-38.649
4	8.29053	5.49E-17	0.000424823	-36.739
5	8.9069	2.57E-19	0.00055543	-34.795
6	9.42722	2.08E-21	0.000718801	-32.832
7	9.76613	7.79E-23	0.000920044	-30.855
8	9.89721	2.12E-23	0.00116854	-28.869
9	9.64992	2.42E-22	0.00145903	-26.877
10	9.16792	2.35E-20	0.00180107	-24.887

Table 5: Results for Post Compensation of DCF at inputs from 1dbm to 10dbm

Iterations	Q factor	BER	Eye Height	Power (dbm)
1	6.8305	1.04E-12	0.000186	-42.5
2	7.46805	3.91E-14	0.00025	-40.647
3	8.11492	2.40E-16	0.0003316	-38.74
4	8.80386	6.56E-19	0.0004352	-36.8
5	9.33	5.20E-21	0.0005621	-34.85
6	9.8	5.31E-23	0.000722	-32.88
7	10.11	2.42E-24	0.000917	-30.9
8	10.14	1.73E-24	0.00115	-28.92
9	9.84	3.46E-23	0.00142	-26.93
10	9.2	1.69E-20	0.00173	-24.954

Table 6: Results for Symmetrical Compensation of DCF at inputs from 1dbm to 10dbm

Iterations	Q factor	BER	Eye Height	Power (dbm)
1	3.1	8.86E-04	3.20E-06	-48.89
2	3.62	1.30E-04	2.71E-05	-48.19
3	4.22	1.07E-05	4.41E-05	-47.26
4	4.9	4.19E-07	7.39E-05	-46.11

5	5.61	8.72E-09	1.10E-04	-44.74
6	6.37	7.93E-11	1.57E-04	-43.18
7	7.1	5.23E-13	2.10E-04	-41.5
8	7.8	2.69E-15	2.80E-04	-39.7
9	8.36	2.74E-17	3.70E-04	-37.84
10	8.69	1.49E-18	4.70E-04	-35.94

Comparative Results Of Different Configurations For 1-10dbm Input Power

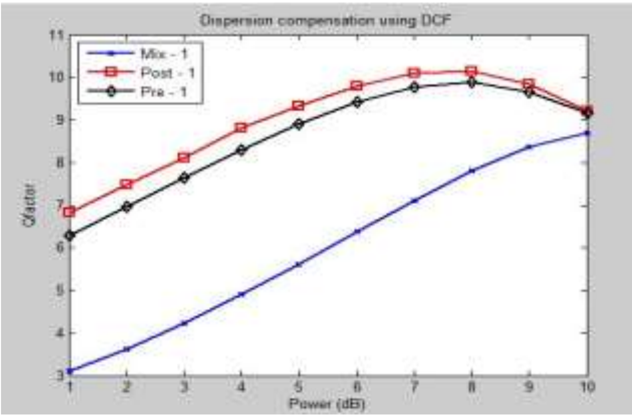

Figure 11:Input Power Vs Q- Factor Plot

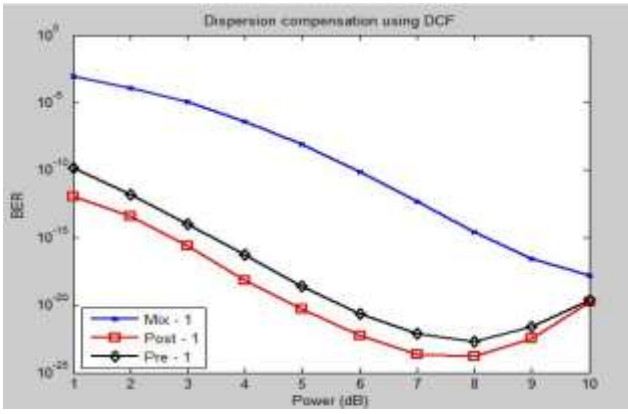

Figure 12: Power Vs BER Plot

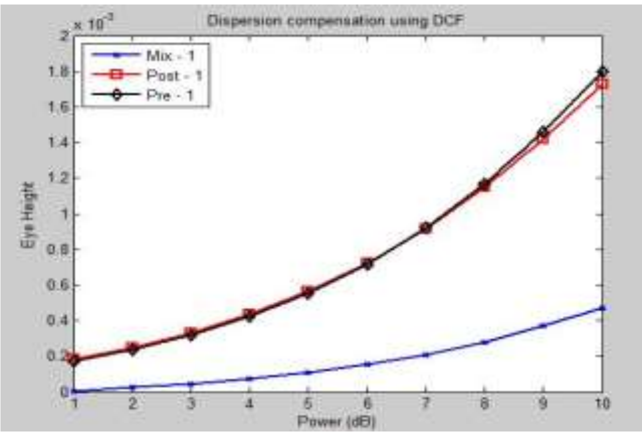

Figure 13:Power Vs Eye Height Plot

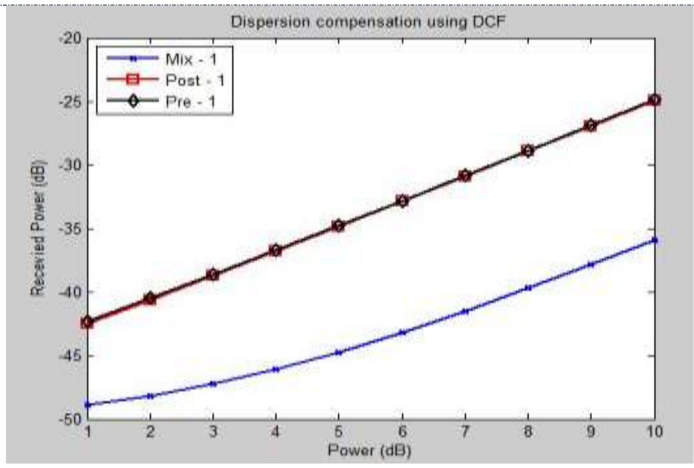

Figure 14:Input Power Vs Received Power Plot

IV. CONCLUSIONS

During the transmission of signals over large distances, chromatic dispersion is turning into a central point to decay the quality of signal. The work in this paper is completely centered onexpelling dispersion by using DCF in various schemes that is showed in simulations. We have used DCF of 24km at a rate of 100Gbps for a distance of 120km to analyze the performance of the system in pre compensation, post compensation and symmetrical compensation.All the three schemes has been analyzed for input powers ranging from 1-10dBm in terms oftheir quality factor, bit error rate, eye height and received power as shown in Fig-11, 12, 13 and 14, respectively.After evaluating, it is clear from the simulation results that Post Compensation is providing better outcomes among all other schemes.

V. REFERENCES

[1] M.Kaur and H.Sarangal, "Analysis on Dispersion Compensation with Dispersion Compensating Fiber," SSRG International Journal of Electronics and Communication,vol. 2,Issue no. 2,pp. 56-59,February,2015.
[2] G. Singh, J. Saxena and G. Kaur, "Dispersion Compensation Using FBG and DCF in 120Gbps WDM System, "International Journal of Engineering Science and Innovative Technology, vol. 3, Issue no. 6, pp. 514-519, November, 2014.
[3] Mr.G.H.Patel, Prof. R.B.Patel and Prof. S.J. Patel, "Dispersion Compensation in 40Gb/s WDM network using Dispersion Compensating Fiber," Journal of Information,Knowledge and Research in Electronics and Communication Engineerring,vol. 2,Issue no. 2,pp. 662-665.
[4] Rajani, R.Pal and V. Sharma, "Comparison of Pre,Post and Symmetrical Dispersion Compensation Schemes for 10/15Gb/s using different Modulation Formats at various Optical Power Levels using Standard and Dispersion Compensating Fibers," International Journal of Computer Applications,vol. 50, Issue no. 21, pp. 06-13, July, 2012.
[5] G.Gnanagurunathan and Faidz A. Rahman, "Comparing FBG and DCF as Dispersion Compensators in the long haul narrowband WDM systems ,"International Conference on Wireless and Optical Communication Networks (IEEE Xplore),2006.
[6] Gopika P and S.A. Thomas, "Performance Analysis of Dispersion Compensation using FBG and DCF in WDM systems," IJARCCE, vol. 4, Issue no. 10, pp. 223-226, October, 2015.
[7] V. Senthamizhselvan, R. Ramachandran and R. Rajasekar, "Performance Analysis of DWDM based Fiber Optic Communication with different Modulation Schemes and Dispersion Compensation Fiber," International Journal of Research in Engineering and Technology, vol. 3, Issue no. 3, pp. 287-290, March, 2014.
[8] N. K. Kahlon and G. Kaur, "Various Dispersion Compensation Techniques For Optical System: A Survey,"Open Journal of Communications And Software, vol. 1, Issue no. 1, pp. 64-73, May, 2014.
[9] A. Mohan, S. Nath P, S.B. Johnson and A. Sangeetha, "Compensation of Dispersion in 5Gbps WDM system by using DCF,"Green Computing Communication and Electrical Enginnering (ICGCCEE), pp. 1-5, 2014 .

ISSN: 2277-9655
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CODEN: IJESS7

[10] Sabina and M. Kaur, "Performance Comparison of Pre, Post and Symmetrical Dispersion Compensation using DCF for 64*40 Gbps DWDM System," SSRG-International Journal Of Electronics and Communication Engineering,vol. 4,Issue no. 7, pp. 1-6, July, 2017.

[11] B. HU, W. Zing, W. Wei and R. Zhao, "Analysis on Dispersion Compensation with DCF based on Optisystem," 2nd International Conference on Industrial and Information Systems (IEEE), 2010.

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