Performance Analysis of WDM Link Using Different DCF Techniques at 20 Gb/s

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Abstract— **In this paper, compare performance of pre, post, and symmetrical dispersion compensation technique for 16 channels at 20 Gbps non-return to zero WDM system using dispersion compensating fiber (DCF) and single mode fiber (SMF). In this work we used DCF techniques to compensate dispersion in optical fiber communication. The Various factors like chromatic dispersion, polarization mode dispersion, non-linear effects, second and third order dispersion impose limit on the performance (transmission distance, pulse broadening) of Wavelength division Multiplexing (WDM) transmission system. The results of three compensation techniques have been compared in the term of bit error rate, eye and Quality factor and it is found that symmetrical compensation methods are provide better results for long haul communication. Pre and Post compensation scheme are also provide better result but on comparison of these three schemes the symmetrical compensation perform better then other. The impact of bit error rate and eye closure penalty is also observed for large transmission distances and cover 240 km using symmetrical-compensation method with acheived bit error rate (2.36173×10^{-89}) and quality factor (19.9934 dB).**

Keywords: **Wavelength Division multiplexing, Pre, post and symmetrical-dispersion compensation, DCF.**

I. Introduction

Optical signal of different wavelength (1300-1600nm) can propagated without interfering with each other. The scheme of combining number of wavelength over a single fiber is known as wavelength division multiplexing (WDM). Each input is generated by separate optical source with a unique wavelength. [1] The first generation light wave systems operating near 800nm started early in the 70's. During that period of time, it was realized that the repeaters spacing could be increased by operating the light wave system in the wavelength region near 1300nm, where the fiber loss is generally below 1dB/ km. This limitation was overcome by the use of single-mode fibers (SMFs). The third generation systems of 1550nm become available commercially. The fourth generation of light wave systems is concerned with an increase in the bit rate through frequency-division multiplexing and respective wave-division multiplexing techniques, and an increase in the repeaters spacing through optical amplification. [2] In WDM network, dispersion, Group velocity dispersion (GVD) and nonlinear effects, like self phase modulation, cross phase modulation and four-wave mixing is observed at different data rates. So this dispersion and fiber nonlinearities at different data rate must to be minimized by different dispersion compensation techniques like dispersion compensation fiber, fiber Bragg grating, optical phase conjugation and electrical compensation methods.[5]In this paper used dispersion compensation fiber to compensate dispersion in WDM link, that reduce the dispersion and increase the transmission distance. Considering all these compensation methods the dispersion compensating fibers has been deployed in this work. Dispersion compensating fibers(DCFs) are used in this study so as to reduce the overall dispersion of the optical link as they have higher negative dispersion coefficient and can be connected to standard single mode fiber(SSMF) having positive dispersion coefficient. It overcomes the pulse broadening in the SSMF. In this investigation used three compensation techniques to compensate dispersion in optical fiber. The dispersion compensating fiber can be connected either through pre, post or symmetrical compensation scheme.

II. Chromatic Dispersion Management

Chromatic Dispersion Management (CDM) is very important in high speed WDM transmission. After some transmission distance, the accumulated CD causes pulse distortion. However, the information carried is not lost and can be recovered if the distorted pulses are restored [10]. This fiber has zero dispersion at 1550nm wavelength and works well in a single channel transmission. However in reconfigurable optical networks, where the wavelength changes its path, the accumulated dispersion always changes. So the group velocity dispersion (GVD) is occurring in optical fiber and this can be managed by dispersion compensation fiber. [7]

III. Dispersion Management Scheme

Dispersion compensation in WDM system operating at different wavelength can be achieved by employing by dispersion mapping techniques. In this techniques fibers of opposing dispersion coefficient are made to alternate along the length of optical link. In general negative dispersion fiber(NDF) have a large dispersion in comparison to standard SMF's, thus a relatively short NDF can compensate for

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Dispersion accumulated over long links of SMFs.[11] Dispersion mapping with Negative dispersion fiber(NDF) and positive dispersion fiber (PDF) shown in figure 1.

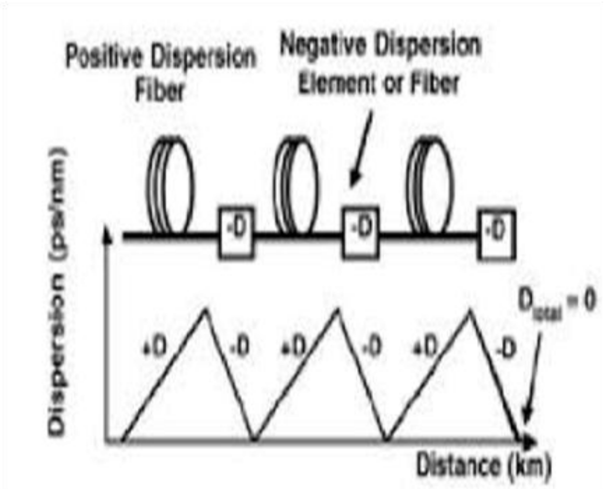

Figure1: Dispersion management map

Figure 1 shows the dispersion in optical fiber. There are two types of dispersion i.e. positive dispersion and negative dispersion in fiber and this can be compensated by placing one DCF with negative dispersion after a SMF with positive dispersion, the net dispersion will be zero[3].Dispersion compensated fibers are specially designed fibers with negative dispersion. The high value of negative dispersion is used to compensate for positive dispersion over large lengths of ordinary fiber. [12] Spans made of single mode fibers and dispersion compensated fibers are good candidates for long distance transmission as their high local dispersion is known to reduce the phase matching giving rise to four waves in WDM systems. [6],[8].

IV. Dispersion Compensating Fiber

In order to meet the growing demand of bandwidth for internet and other related communication applications, future long-haul systems are required to operate at bit-rate of 10 Gbit/s, 40 Gbit/s or even higher. In high capacity systems, dispersion compensation is critical. The transmission fibers in the existing network are the standard non-zero dispersion fibres (NZDF) 5 with nominal value for dispersion equal to +17 ps / nm km. Although these fibers were deployed several decades ago, they are still preferred by system designers today because the high dispersion of the fiber is used efficiently to impair the non-linear manifestation of optical fiber in systems. Hence dispersion compensation is required to increase the transmission distance in systems operating at high bit -rates. Furthermore, the DC device is required to have a sufficiently large bandwidth in order to achieve simultaneous compensation across all the channels. This implies that the DC device must be capable of dispersion slope compensation. Several dispersion and dispersion slope compensating devices have been demonstrated, including single-mode and higher-order-mode dispersion compensating fibers. [9] Dispersion Compensating Fiber (DCF) is a popular solution to compensate the dispersion after every span which is suitable for WDM systems. Therefore, the DCF length required is around 4 (SSMF) to 20 (NZDSF) times shorter than the transmission fiber. An Improved methodology for Dispersion Compensation is discussed in this work, which offers much better performance compared to FBG compensation in long haul Optical Fiber Networks [11].

V. SIMULATION SETUP

In this work, sixteen channels are transmitted at 20 Gb/s speed with 100 GHz channel spacing. In this paper, comparison of three compensation technique: pre-, post, and symmetrical using DCF at 20 Gbps WDM System has been investigated. The simulation schematic consists of 20 Gbps transmitter span and receiver as shown in figure 2. The WDM system is designed using the Optisystem 7.0 software. The data source used in pre, post and symmetrical compensation scheme is user defined data rate at 20 Gb/s. There are 16 laser sources generating optical signals of different wavelengths. Their wavelengths are selected depending on the channel spacing between the adjacent channels during transmission through single mode fiber. The power level of input signals is 6dBm and best suited power levels are selected.

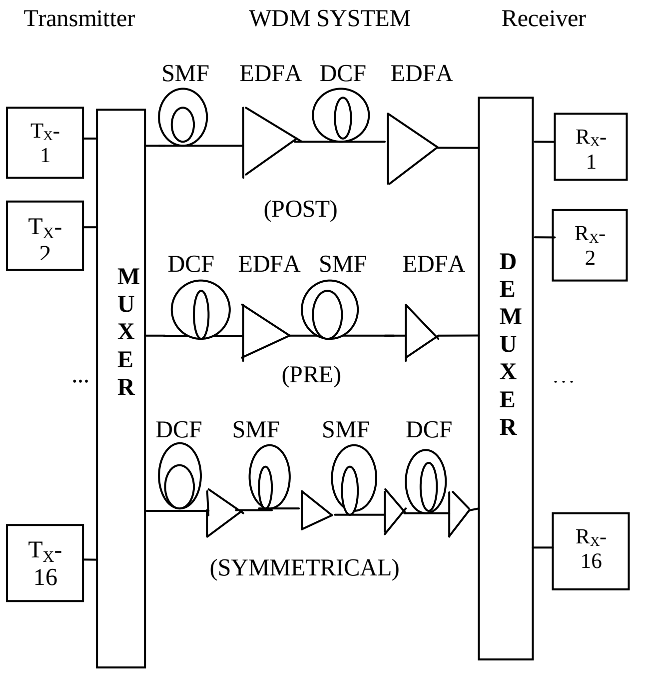

Figure 2: Optimized Link for 16-Channels WDM system using dispersion compensating fiber technique (Pre, Post, and Symmetrical Compensation)

The multiplexer combines the 16 input channels and transmit them over a single channel. The transmission channel contains the SSMF of length 100 km with 17ps/nm/km dispersion coefficient and dispersion compensating fiber of length 20 km with −85 ps/mm/km dispersion coefficient. The number of

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spans is taken to be 4 so total link length is equal to 240km in case of pre and post compensation. In symmetrical compensation 2 DCFs each of 20km length and 2 SSMFs of 100 km length each are used in single span and total link length is same 240km in all three compensation scheme. EDFA amplifiers are used between the links to amplify the signal. At receiver side the 1:16 demultiplexer splits the signals to 16 different channels. The output of demultiplexer is detected by PIN photo detector and passed through Bessel filter. The CW lasers are used with their power levels 6 dbm. The EDFAs are of gain control type with noise figure of 6 dB and their gain is adjusted between 12.8dB and 18db. Dispersion of SSMF is 17ps/nm/km and dispersion of DCF is −85 ps/nm/km so that equation D1Ll + D2L2 = 0 is satisfied [8]. The Parameter are used in Optimized link are given in Table 1.

Table 1: Simulation Parameter for 8-channel DCF

Parameters	Values
Wavelength	1550nm
No. of Channel	16
Modulation Scheme	NRZ
Data Rate	20Gb\s
Light Source (TX)	CW laser
Fiber	SMF
Receiver used (RX)	PIN
Fiber Length (SMF)	100 Km
DCF Length	20 Km
Power	6dbm
EDFA gain	12.8 and 18 db
MZM Ratio	30db
Dispersion coefficient of SMF	17ps/nm/km

Table 1 shows the Parameter used in simulation link for 16-channel dispersion compensation fiber.

VI. RESULT AND DISCUSSION

In this work demonstrate the optimized link for WDM link using Different DCF techniques like pre, post and symmetrical compensation scheme at 20 Gbps. Performance of dispersion compensating fiber is analyzed at 1550nm wavelength and compare pre, post and symmetrical compensation scheme and analyzed which scheme has better performance and Better bit error rate. The design of 16-channel WDM link is shown in figure 2, using this link can compare different techniques of DCF. For the sake of simplicity of the work, shows the three best performance of channel out of 16 channels of each compensation techniques of DCF (pre, post, symmetrical) are represent in this paper. Firstly the result are obtained for Pre Compensation Technique at 1550nm wavelength of three best performance channel out of 16-channel, which channel has better performance is represent in this paper.

1) Result for PRE Compensation Technique at 1550nm wavelength

Using Pre compensation technique of DCF which can compensate dispersion in WDM link and transmit data at long distance. In this Compensation scheme, the dispersion compensating fiber of negative dispersion is placed before the standard fiber to compensate positive dispersion of the standard fiber.DCF Pre compensation achieves dispersion compensation by place the DCF before a certain conventional single mode fiber. Figure 3 shows performance of first channel of pre compensation scheme. In this work analyzed the performance of 16-channel of WDM System and in this paper shows best performance of channels out of 16 channels.

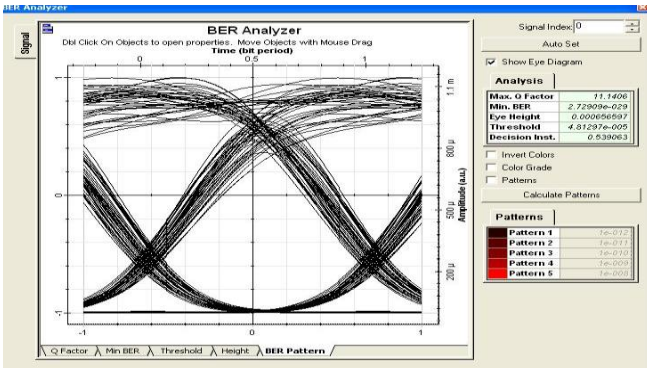

Figure 3: Eye diagram analysis for first Channel of Pre Compensation Technique at 1550nm Wavelength

As shown in eye diagram 3 at 1550nm in pre compensation scheme using Dispersion compensating fiber that provide Q-factor of 11.1406 and BER of 2.72909e-029. The reference value of Q factor is 7 with an acceptable BER of 10^{-12}.The result shows performance of first channel is good and gives higher performance then acceptable value. Figure 4 shows performance of second channel of pre compensation scheme and this represent performance of first channel is higher then second channel. Performance second is also better but on comparison first is better then second channel of pre compensation.

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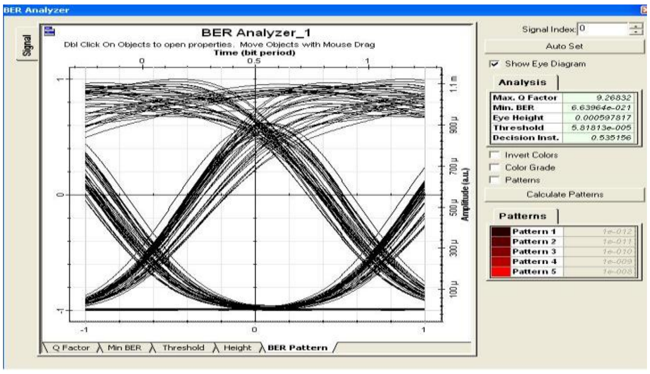

Figure 4: Eye diagram analysis for Second Channel of Pre Compensation Technique at 1550nm Wavelength

As shown in figure 4 performance of second channel is providing Q-Factor of 9.26832 and BER of 6.6394e-021.

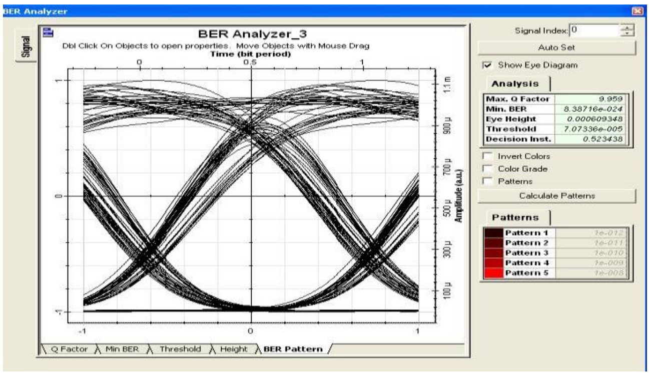

Figure 5: Eye diagram analysis for 4th Channel of Pre Compensation Technique at 1550nm Wavelength

In this figure represent performance of 4th channel of pre compensation technique that provide Q-factor is 9.959 and BER is 8.38716e-024.This demonstrate performance of fourth channel is better then 2nd channel of pre–compensation scheme. The result of second channel also acceptable and are in permissible limit.

2) Performance analyzed for Post compensation Technique

In this Compensation scheme, the dispersion compensating fiber of negative dispersion is placed after the standard fiber to compensate positive dispersion of the standard fiber. The figure of three dispersion compensation systems is shown in Figure 2.In this paper shows best performance of three channels out of 16 channels for the sake of simplicity of the work. Figure 6 described performance of first channel of post compensation scheme that provide Q-factor is 14.658 and BER is 4.96996e-049. This channel performs better then pre compensation technique and produce higher Q-factor and BER. As shown in figure 7 performance of second channel provide Q-Factor of 15.4956 and BER is 1.54471e-054.Performance of this channel is higher then first channel. Overall results indicate that performance of Post- compensation technique is better then Pre-compensation.

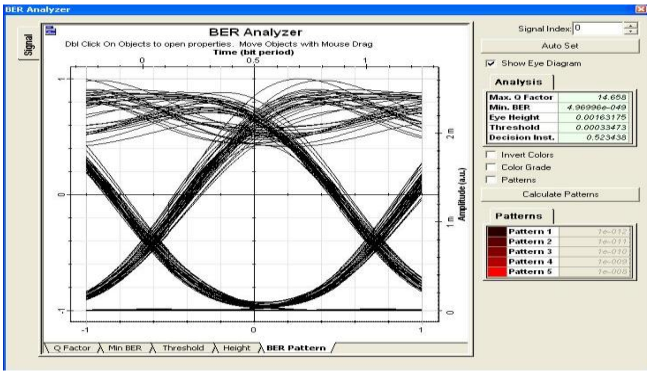

Figure 6: Eye diagram analysis for 1st Channel of Post Compensation Technique at 1550nm Wavelength

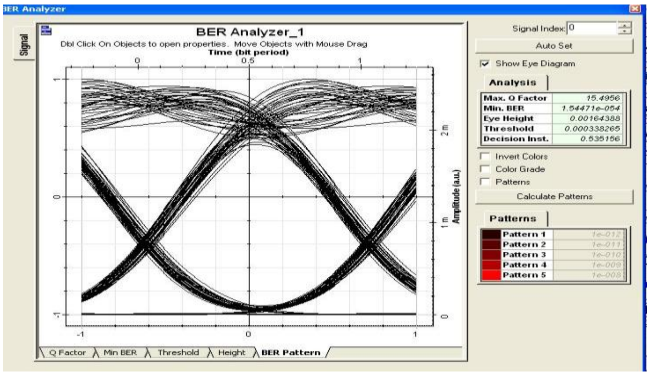

Figure 7: Eye diagram analysis for 2nd Channel of Post Compensation Technique at 1550nm Wavelength

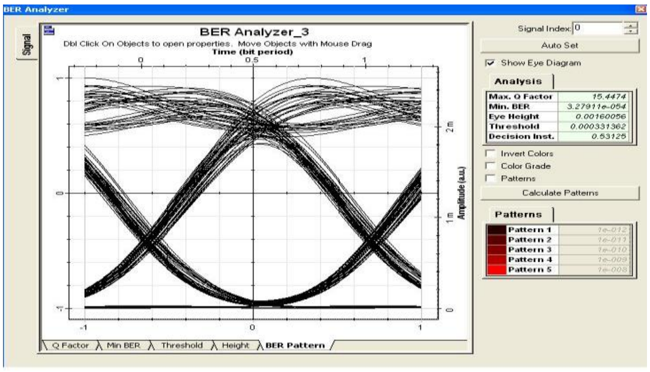

Figure 8: Eye diagram analysis for 4th Channel of Post Compensation Technique at 1550nm Wavelength

The eye diagram for fourth channel of Post compensation at 1550nm wavelength shown in figure 8.The eye diagram at 20Gbps data rate, the Q-factor and BER are respectively 15.4474 and 3.27911e-054 and this shows performance is almost same in case of 2nd channel and 4th channel.

3) Compare with Symmetrical Compensation Technique

In this Compensation scheme, the dispersion compensating fiber of negative dispersion is placed before and after the

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standard fiber to compensate positive dispersion of the standard fiber. In this technique used 2 DCF to compensate dispersion in WDM Link and 2 SSMF to compensate positive dispersion each of length is 100 km and DCF length is 20 km . In figure 9 shows performance of first channel of Symmetrical compensation technique provide Q-factor is 19.3714 and BER is 5.01383e-084.

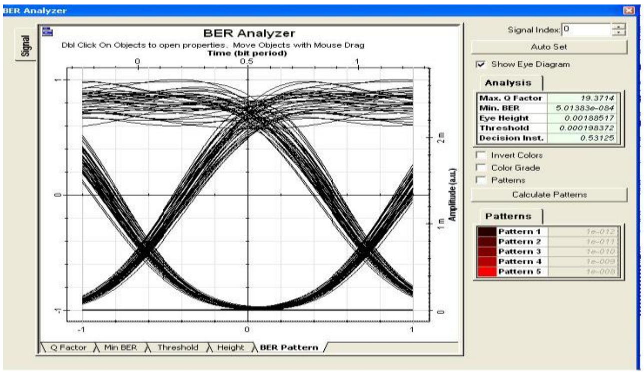

Figure 9: Eye diagram analysis for first Channel of Symmetrical Compensation Technique at 1550nm Wavelength

The eye diagram 10 shows the Q-factor of second channel for Symmetrical at 1550nm wavelength; provide Q-Factor is 19.9934 and 2.36173e-089. This shows the performance of second channel is better and used for higher data rate and represents that the time delays in the received bits are negligible and the signal distortion due to BER is tolerable.

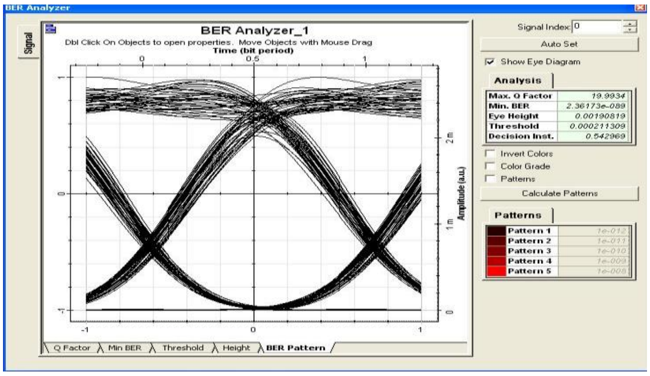

Figure 10: Eye diagram analysis for 2nd Channel of Symmetrical Compensation Technique at 1550nm Wavelength

Using Symmetrical technique achieved better performance of optical link using dispersion compensating fiber (DCF). As shown in eye diagram 11 performance of 4th channel at 1550nm wavelength provide Q-factor is 17.6136 and 7.86369e-070. This shows link gives higher performance then Pre and Post compensation Technique and it is efficient for long distance communication without dispersion at higher data rate.

The effect of dispersion compensation is very good and signal quality is high, eye opening is good in case of Symmetrical compensation.

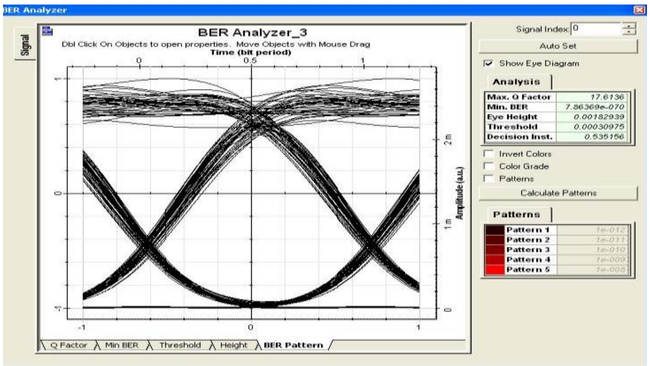

Figure 9: Eye diagram analysis for 4th Channel of Symmetrical Compensation Technique at 1550nm Wavelength

The Overall result indicates that comparison of different Techniques of DCF at 20 Gbps Data rate and conclude that symmetrical compensation perform better in terms of Q-factor and BER and transmit data at long distance. Comparison of DCF Techniques in terms of Q-factor and BER are given in Table 2.

Table 2: Comparison of Different techniques of DCF

Scheme	Channel No.	Q-factor	BER
Pre Compensation	1st	11.1406	2.72909e-029
Pre Compensation	2nd	9.26832	6.63994e-021
Pre Compensation	4th	9.959	8.38716e-024
Post Compensation	1st	14.658	4.969966e-049
Post Compensation	2nd	15.4956	1.54471e-054
Post Compensation	4th	15.4474	3.27911e-054
Symmetrical Compensation	1st	19.3714	5.01383e-084
Symmetrical Compensation	2nd	19.9934	2.36173e-089
Symmetrical Compensation	4th	17.6136	7.86369e-070

Table 2 Shows Comparison of different techniques at different channel and specify best performance of channels out of sixteen channels for each technique and compare them, as can see from different eye diagram and comparison table, the Symmetrical compensation Technique has better Q-factor and min BER as compared to other Pre and Post Technique Through the whole system analysis found that the performance of WDM link at 1550nm wavelength for symmetrical compensation is best in long distance high speed WDM Systems.

VII. CONCLUSION

In this work, optimized and analyzed the performance of 16-channel at 20 Gbps of WDM network. All the results have been compared and analyzed in terms of Q-factor, Bit error rate. The efficient performance of the link can be achieved by assuming threshold level of BER and Q-factor value which is dynamically set at 10^{-9} and 7 respectively. The different

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techniques used to analyze the performance of proposed link and select those channel which has best performance and that channel represent in this paper. At the end Simulation results shows that using Symmetrical Compensation, conclude that Q-Factor is 19.9934 and Min BER is 2.36173e-089 that represent better performance as compared to Pre and Post Compensation technique. Performance of Pre and Post Compensation are also good but on comparison of these techniques Symmetrical Compensation has higher performance.

VIII. REFERENCES

[1]V. Senthamizhselvan, R. Ramachandran, 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, Volume: 03, Issue: 03, Mar-2014.

[2] Suliman M. Abu–Gazleh, Ali A. Eyadeh, Idrees S. Al-kofahi and Qusai A. Quran, "Theoretical and experimental investigation of fiber loss and dispersion effects in optical networks", journal of Electron and Devices,Vol.18,2013,pp.1524-1530,ISSN:1682-3427.

[3] Chaya S, Ramjan Khatik, "Comparison of Fiber Based Dispersion Compensation in RZ and NRZ Data Modulation Formats", International Journal of Electronics Communication and Computer Technology (IJECCT), Volume 3, Issue 1, January 2013.

[4] Ajeet Singh Verma, A. K. Jaiswal, Mukesh Kumar "An Improved Methodology for Dispersion Compensation and Synchronization in Optical Fiber Communication Networks", Paper was published in International Journal of Emerging Technology and Advanced Engineering Volume 3, Issue 5, May2013.

[5] Mr. Gaurang.H. Patel, Prof. Rohit.B. Patel, Prof. Sweta J. Patel, "Dispersion Compensation in 40 Gb/S WDM Network Using Dispersion Compensating Fiber", journal of information, knowledge and research in electronics and Communication engineering, ISSN: 0975– 6779, Nov 12 to Oct 13, volume – 02, issue - 02 page 662-665.

[6] Rajani , Raju Pal, Vishal Sharma, "Comparison of Pre-, Post- and Symmetrical-Dispersion Compensation Schemes for 10/15Gbps using Different Modulation Formats at Various Optical Power Levels using Standard and Dispersion Compensated Fibers", International Journal of Computer Applications (0975 – 8887) Volume 50– No.21, July 2012.

[7] Ravi Prakash Shukla, Mukesh kumar, A.K. Jaiswal, Rohini Saxena, "Performance Analysis of Dispersion in Optical Communication link Using Different Dispersion Compensation Fiber (DCF) Models", International journal of recent technology and Engineering, ISSN:2277-3878,Vol. 1,june 2012.

[8] Ramesh Pawase, R.P.Labade,.S.B.Deosarkar, "Dispersion Post-Compensation Using DCF at 10Gbps", Global Journal of Computer Science and Technology, Volume 11, Issue Version 1.0, March 2011.

[9] Mr.Ramesh Pawase, Mrs. R.P.Labade, Dr.S.B.Deosarkar, "Dispersion Post-Compensation Using DCF at 10GBPS". Global Journal of Computer Science and Technology Volume 11 Issue Version 1.0 March 2011.

[10] M. Guy, and Y. Painchaud, "Fiber Bragg Gratings: A Versatile Approach to Dispersion Compensation", Photonics Spectra, Aug. 2004, pp. 1-7.

[11] R.S. Kalera, Ajay K.Sharma , T.S. Kamala, "Comparison of pre- ,post- and symmetrical-dispersion compensation schemes for 10 Gb/s NRZ links using standard and dispersion compensated fibers" Optics Communications 209 ,2002,pp. 107–123.

[12] C.Peuchere t, N.Hanik, R.Freund, L.Molle, P. Jeppesen, EEE Photon.Technol.Lett.12 (8), 2000 992.

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