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Analysis on Dispersion Compensation For Long Haul DWDM System Using Different Input Pulses

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Abstract

In a long haul WDM optical system dispersion is the main issue that hinders the reliable communication. For this reason a lot of research is going on to reduce the dispersion by using different dispersion compensation techniques and for the selection of proper line encoding. In this paper DWDM system isanalyzed for different dispersion compensation techniques using DCF with different input pulse formats at 10 Gb/s for long haul optical system. The results show that a third order Gaussian pulse with symmetrical compensation scheme provides the minimum BER and is recommended and suitable to use. The tool used for the simulation was optisystem.

Index Terms- Wavelength Division Multiplexing (WDM), Dispersion Compensation, Dense Wavelength Division Multiplexing (DWDM) , BER.

I. INTRODUCTION

Due to high data rate, low loss and large transmission distance the use of optical networks is increasing day by day. This leads to the replacement of traditional networks and also with the advent of Wavelength division multiplexing the optical communication system has reached a different level. A WDM system involves the transmission of a number of different optical signals in parallel on single optical fiber. A conventional WDM system involves multiplexed signals with a channel spacing between 200 and 100GHz. But now these days to increase channel capacity and to reduce bandwidth requirements WDM systems with channel spacing of 50GHz, called Dense WDM system, have been used[1].

For a long haul WDM optical communication system, due to different fiber losses the OSNR of the transmitted signal degrades with distance. To compensate for these losses optical amplifiers have to be incorporated after certain distance. EDFAs operates in the 1550nm wavelength can provide desired signal amplification. But, it also increases the non-linear effects and dispersion. For a long haul DWDM system there is a greater need of dispersion compensation. So, in order to realize high data rate over a long distance several methods have been proposed to overcome these impairments including fiber bragg grating, optical phase conjugation, dispersion compensating fibers, and different delay method[2].

In this work dispersion compensating fibers are used to reduce the overall dispersion of the optical link. DCFs have the negative dispersion coefficient and can be connected to SMFs (single mode fibers) having positive dispersion coefficient to neutralize overall dispersion effect. This combined use of DCF and SMF different configuration provided Pre, Post and Symmetrical- compensation schemes.

This paper is based on the study of long haul DWDM system for different optical pulses for different compensation schemes. Section II, describes the block diagram and system parameters. In section III the results have been compared and section IV shows the conclusions drawn from the results.

II. SYSTEM DESCRIPTION

A 16:1 DWDM system is made using pre, post and symmetrical compensation schemes as shown in Figure 1. Transmitter includes pseudo random bit sequence generator, optical pulse generator, CW laser and match zehnder modulator as shown in Figure.2. Four input pulses i.e. NRZ, RZ, Duo-binary and Gaussian pulses have been analyzed for different compensation schemes. The input laser power is varied between -6dbm and 6dbm for each pulse. Duo-binary, RZ and Gaussian shows best results at 6dbm while 0dbm power is suitable for NRZ format. Since more multiplexed signals can be used for DWDM system[3]. The output of the each transmitter is multiplexed using 16:1 WDM multiplexer. The transmission channel contains a SMF of length 50kms with 17ps/nm/km and DCF of 10kms and dispersion coefficient of -85ps/nm/km. For pre- and post- compensation schemes the number of spans are taken to be 18, thus making a total transmission distance of 1080kms.Symmetrical compensation contains 2 DCFs and 2 SMFs in each loop. So, numbers of spans are set to 9.

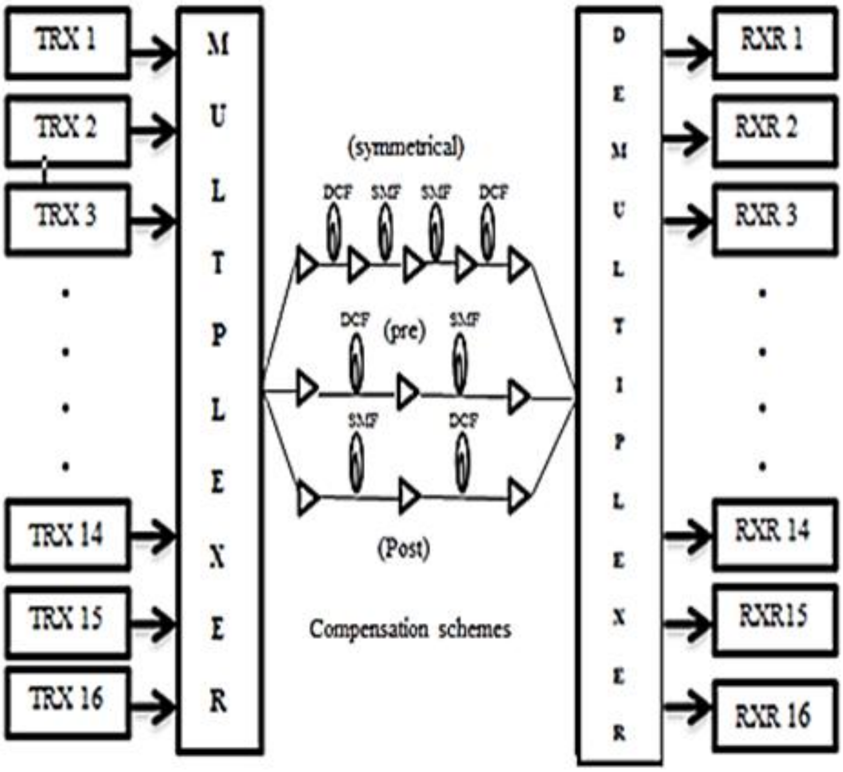

Figure 1. 16 channel DWDM System

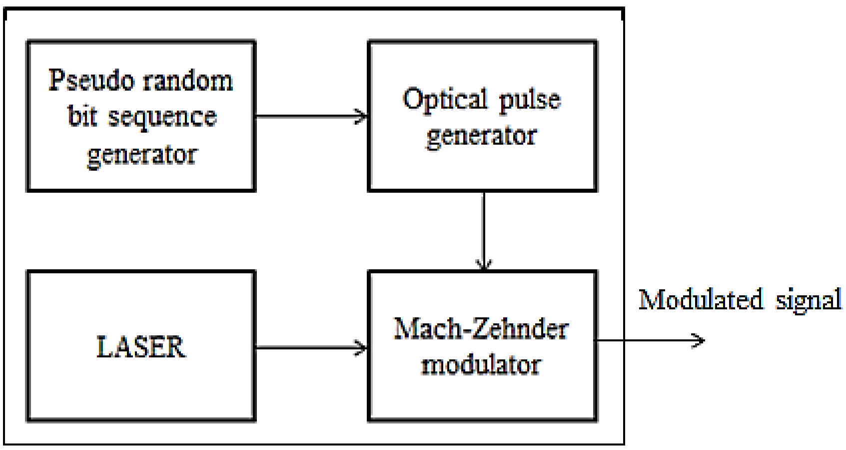

Figure 2. Transmitter Block of DWDM System.

At receiver side WDM demultiplexer splits the optical signal into 16 different channels. Every output of demultiplexer is passed through photo detector and low pass Bessel filter. The output of the system is analyzed by BER analyzer as shown in Figure 3.

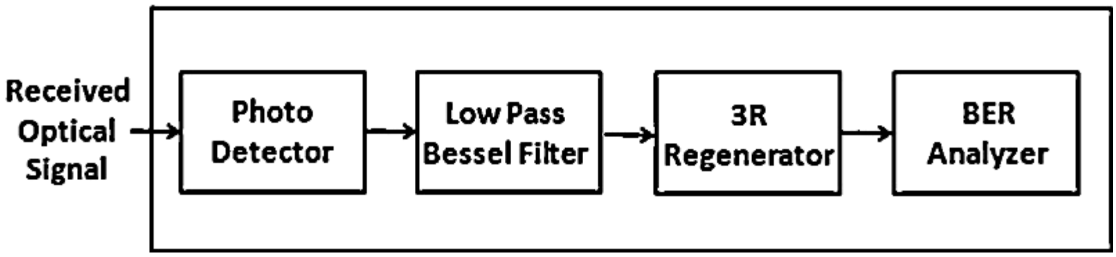

Figure 3. Receiver Block of DWDM System.

Input CW LASERpower is varied from -6dbm to 6dbm for all four input pulses and here the comparison is shown at the input power which gives the best results for different pulses. The length and dispersion coefficients of SMF and DCF are set according to the equation (1):

$$L1 * D1 = D1 * L2 \quad (1)$$

Where *L1*, *L2*, *D1*and *D2*are the length and dispersion coefficient of SMF and DCF respectively[2].

EDFAs are set to as Gain control type with noise figure of 6dbm and gain of 5dbm and 10dbm for DCF and SMF respectively. Attenuation is set to 0.2db/km for SMF and 0.5db/km for DCF.

III. SIMULATION AND RESULTS

In order to determine which compensation scheme is better for different optical pulses. Firstly the optical system for different input pulses has been analyzed for different LASER power i.e. -6dbm, -3dbm, 0dbm, 3dbm and 6dbm. From the simulation results based on BER and Q-factor it was found that RZ, Duo-binary and Gaussian shows best results at 6dbm. While, for NRZ pulse best results are found at 0dbm power. The optical system designs are simulated for a long haul network with total transmission distance of 1080kms at 10Gb/s. The results are shown for 16 channel DWDM system with frequency spacing of 50GHz as shown in table 1.

Table 1. Channel frequency of DWDM System.

Channel no.	Frequency	Channel no.	Frequency
1st	192.1	9th	192.5
2nd	192.15	10th	192.55
3rd	192.2	11th	192.6
4th	192.25	12th	192.65
5th	192.3	13th	192.7
6th	192.35	14th	192.75
7th	192.4	15th	192.8
8th	192.45	16th	192.85

The different parameters such as length and dispersion coefficient of SMF and DCF etc. used in the system design are shown in table 2.

Table 2. Parameters of DWDM System.

Parameter	DCF	SMF
Length	10km	50km
Dispersion coefficient	-85ps/nm/km	17ps/nm/km
EDFA gain	5db	10db
Attenuation	0.5db/km	0.2db/km

A. Gaussian Pulse

A 3rd order super Gaussian pulse has been used for better results with input power of 6dbm[4]. The system is simulated for long haul distance of 1080kms for all three dispersion compensation schemes and the results have been compared on the bases of Q-factor and BER as shown in Figure 4 and Figure 5.

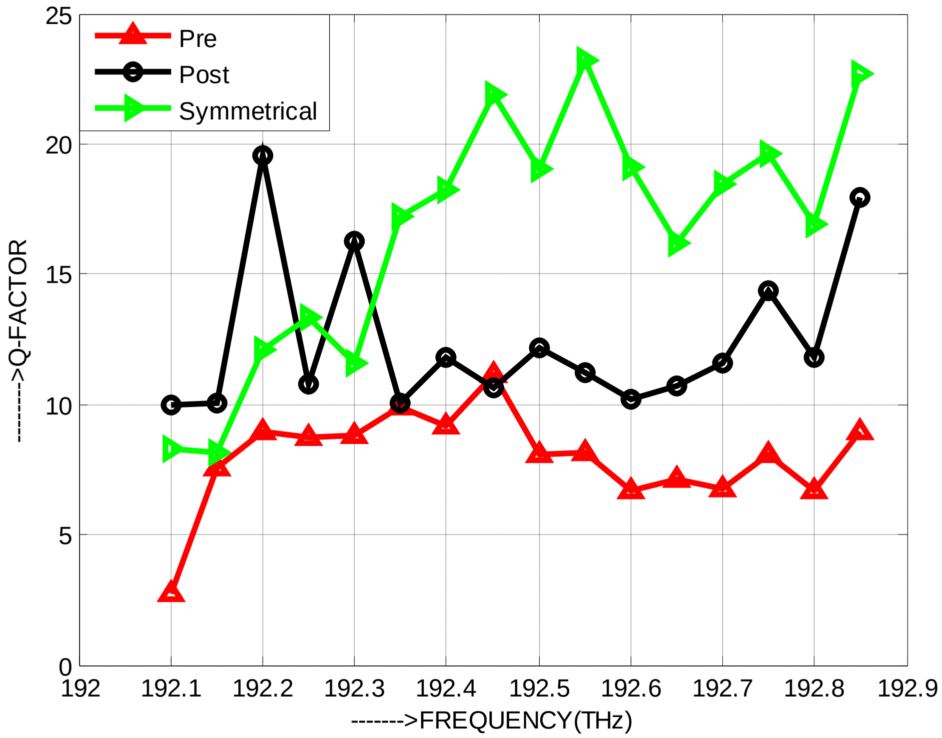

Figure 4. Q factor vs Frequency

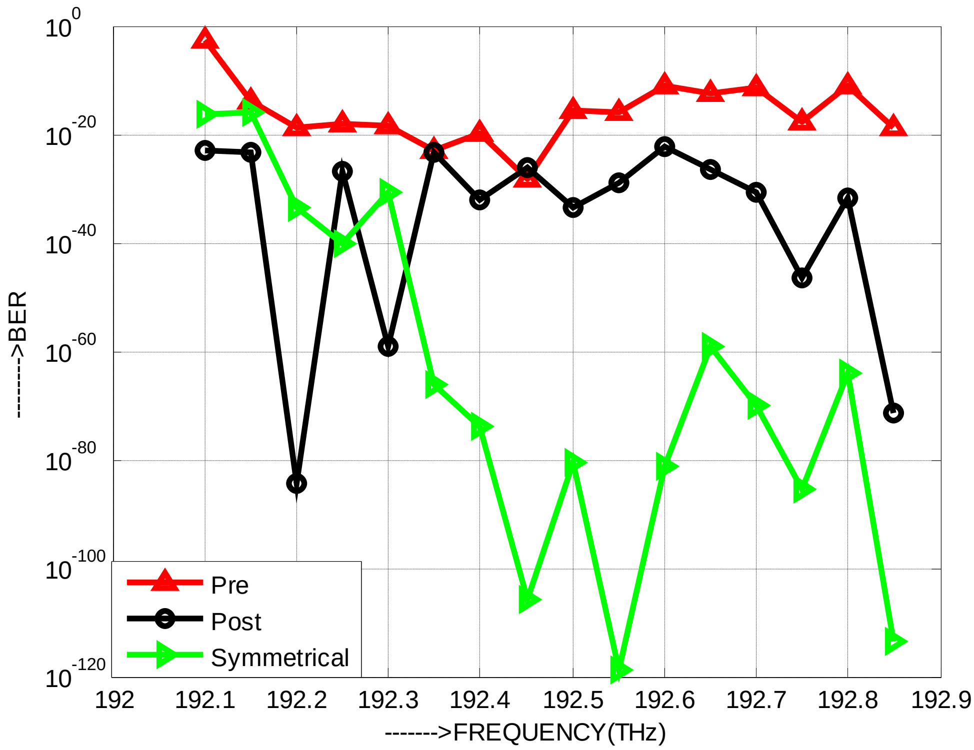

Figure 5. BER vs Frequency

The results shows that symmetrical compensation sheme have the larger Q-factor and lowest BER . Thus for 3rd order Gaussian pulse symmetrical compensation provides the best results followed by post compensation .

B. Duo- Binary Pulse

For Duo-binary pulse the system is also simulated at 6dbm . Figure 6 and Figure 7 shows the Q-factor and BER comparison for pre, post and symmetrical compensation schemes.

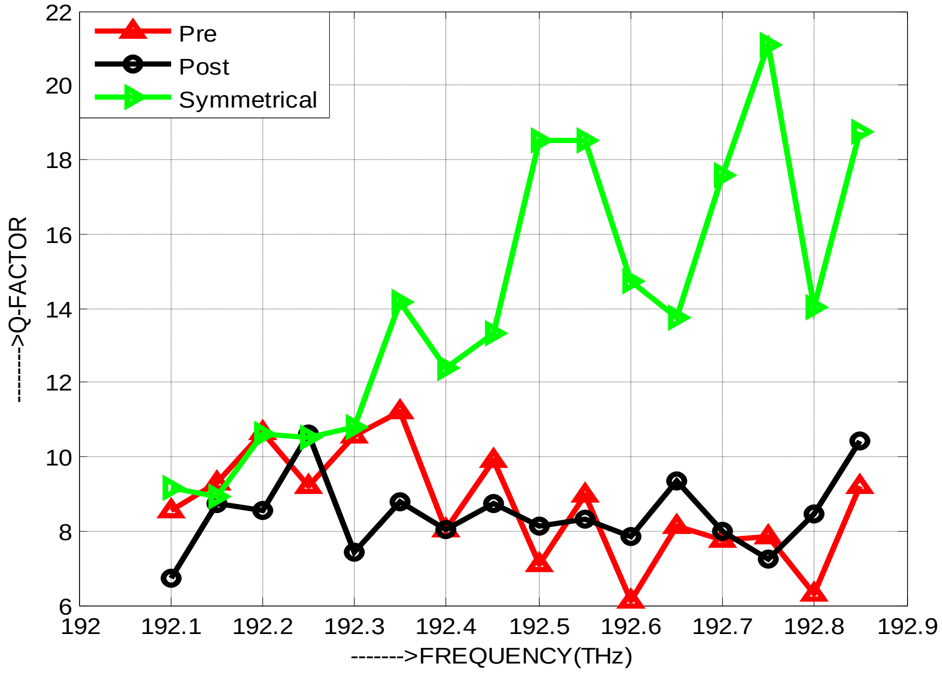

Figure 6. Q factor vs Frequency

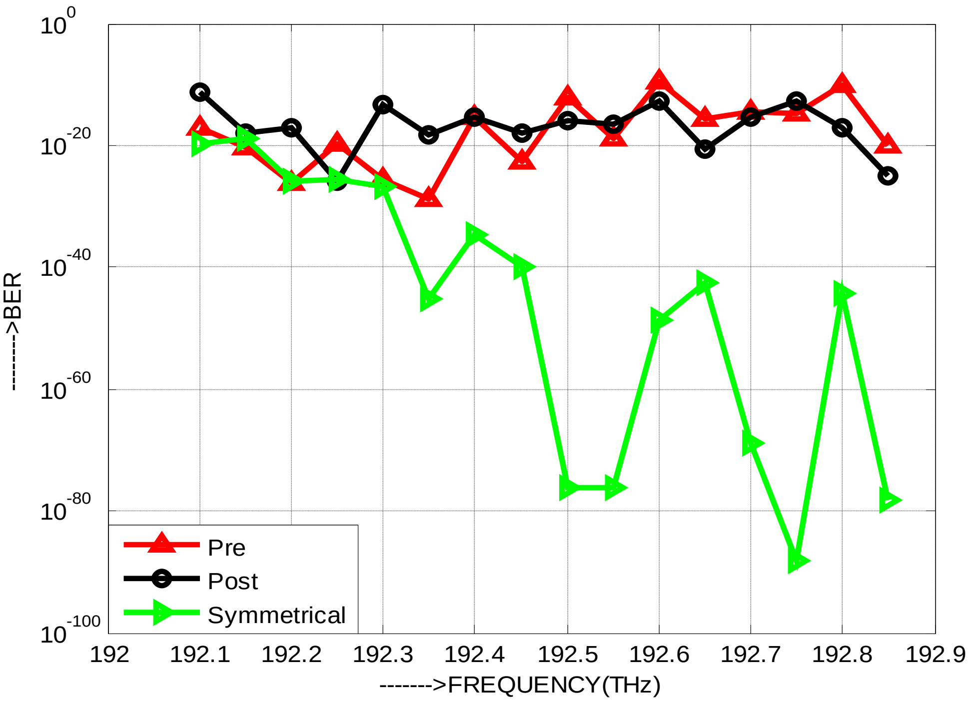

Figure 7. BER vs Frequency

From the graphs it is clear that symmetrical compensation is far better as compared to pre and post compensation. Where both pre and post compensation gives the approaximatly similar results.

C. RZ Pulse

The optical system for RZ Pulse is simulated at 6dbm for a transmission length of 1080kms.The Q-factor and BER for different channels are shown in the Figure 8 and Figure 9.

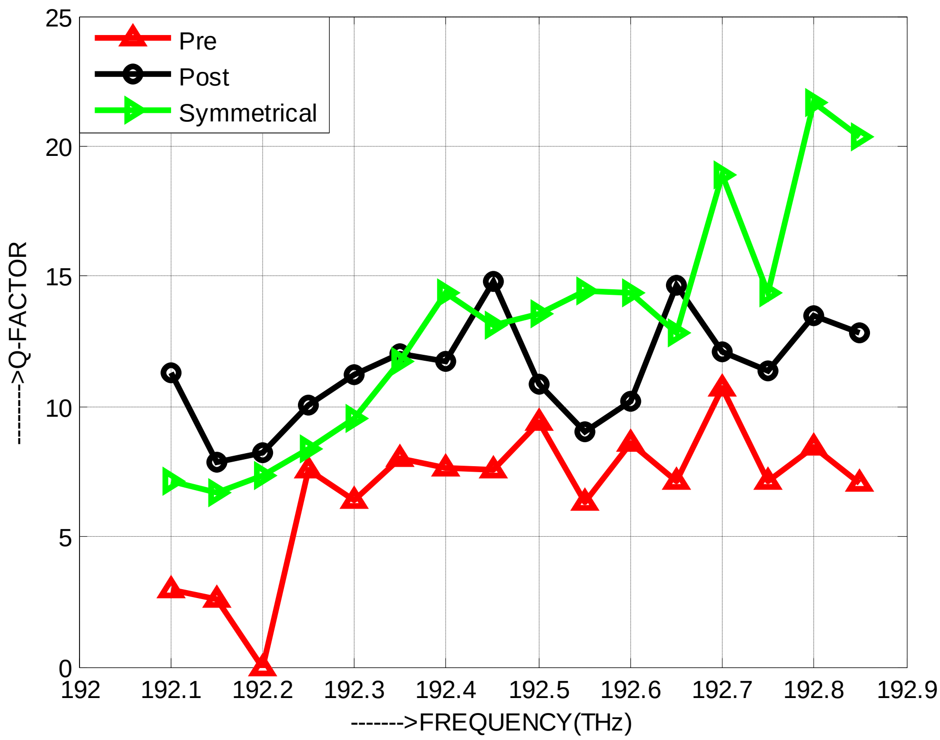

Figure 8. Q factor vs Frequency

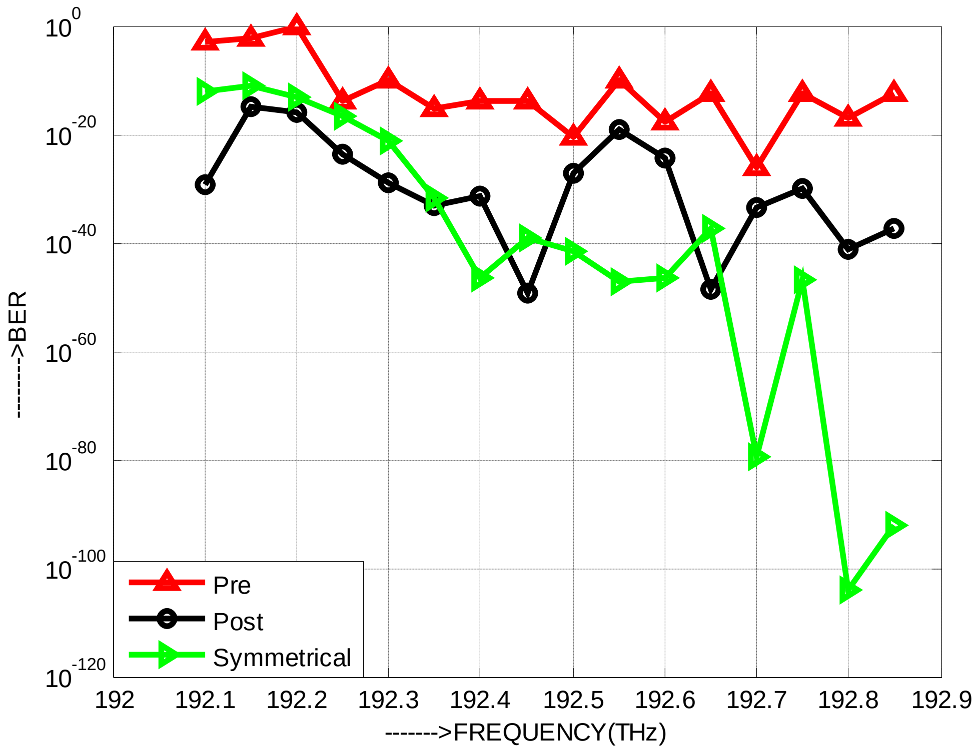

Figure 9. BER vs Frequency

Here for lower frequencies the post and symmetrical have almost similar curves but as the channel frequency increases symmetrical compensation have better results. As the pre compensation has low Q-factor and high BER, it is not recommended to be used for lond haul network have RZ as input pulse.

D. NRZ Pulse

Here the input LASER power is set to 0dbm and Q-factor and BER is calculated for pre, post and symmetrical compensation as shown in figure 10 and figure 11.

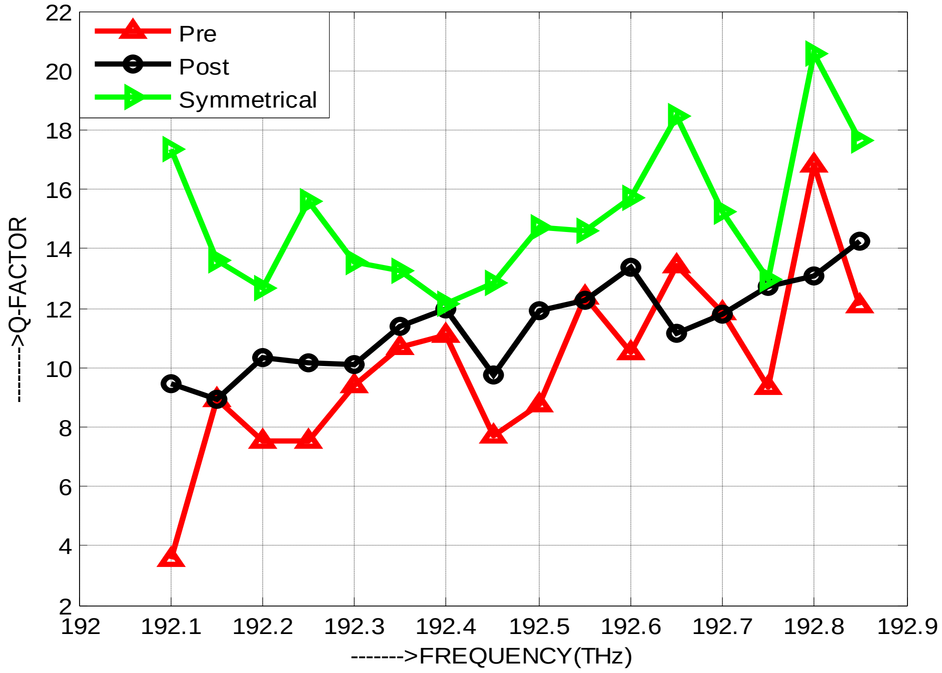

Figure 10. Q factor vs Frequency

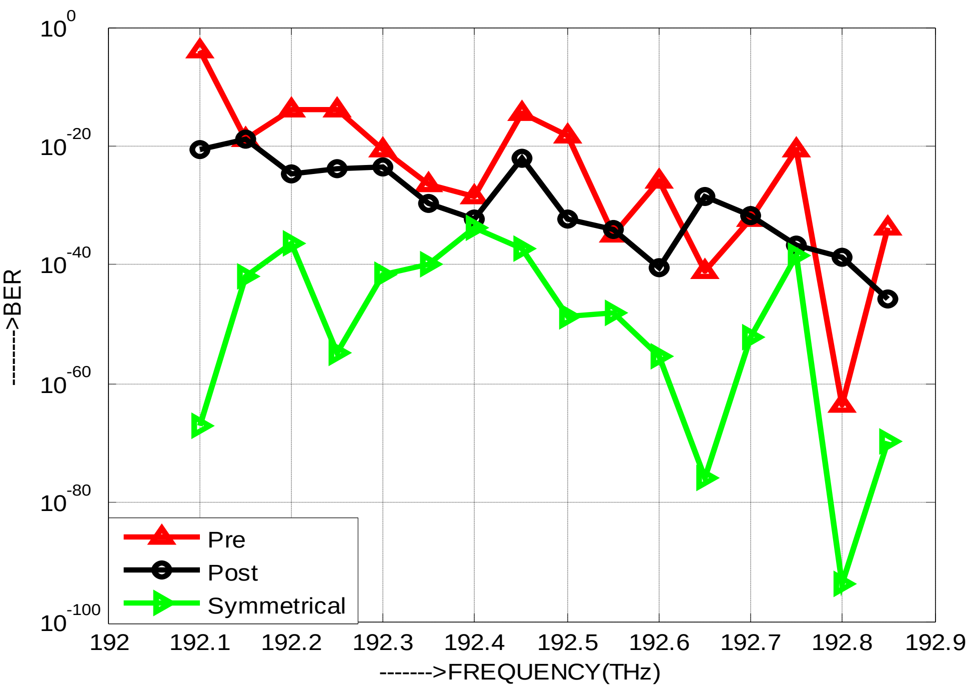

Figure 11. BER vs Frequency

For NRZ format also, the symmetrical compensation gives the min BER and better Q-factor as compared to Pre and post compensation. While pre and post compensation has almost the identical results.

IV. CONCLUSION

In this investigation, the performance of pre, post andsymmetrical compensation technique have been analyzed for NRZ, RZ, Duo-binary and Gaussian pulse inputs. Designs are simulated for 16:1 DWDM system with frequency spacing of 50GHz at long haul optical distance of 1080kms. Symmetrical compensation is found to have the best results for all four input pulses. The performance of Gaussian pulse at 6dbm LASER power is better as compared to other input pulses and distance can be further increased. The symmetrical compensation is recommended for long haul optical network and Gaussian input pulse is useful instead of other input pulses to get high Q-factor and minimum BER.

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