Analysis of Pre-, Post-, and Symmetrical Dispersion Compensation Techniques using DCF on 40 X 10 Gbps WDM-PON System

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***Abstract*- To reduce the dispersion and to improve the overall performance of the WDM-PON system, various dispersion compensation techniques are used in this system. In the optical communication, the dispersion compensation is mainly done by using DCF (Dispersion Compensation Fiber) and FBG (Fiber Bragg Grating). The performance of the system is evaluated at 10 Gbps data rate in the optical by using three different dispersion compensation schemes i.e. is Pre, Post, and Symmetrical Compensation. In this paper, A 40 X 10 Gbps Model is proposed using 40 channels (users) having SMF of length 120 km and DCF of length 24 km. It is concluded from the results that symmetric compensation technique shows better performance as compared to the pre and post. The results are verified on the basis of BER and Q-factor. All the simulation work is done with the help of Optisystem Software version 7.0.**

***Keywords*- Wavelength Division Multiplexing Passive Optical Network (WDM-PON), Dispersion Compensating Fiber (DCF), Single Mode Fiber (SMF), Fiber Bragg Grating (FBG), Q-factor, BER (Bit Error Rate).**

I. INTRODUCTION

The most promising and efficient technique which is used to increase the information-carrying capacity of an optical fiber communication is WDM-PON. It allows signals of multiple wavelengths to transmit simultaneously on the fiber. The main factors due to which transmission in WDM-PON is affected are a chromatic dispersion, attenuation, high power level and other nonlinear effects occurring at high data rates. Optical amplifiers such as EDFA (Erbium doped fiber amplifier), SOA (Semiconductor Optical Amplifier) and Raman amplifier are used to compensate the loss of attenuation in the fiber. From which it is observed that EDFA shows better performance at 1550 nm in the third wavelength window [1] [2]. The dispersion compensation is the main issue in the WDM optical networks. Various types of techniques and methods like optical phase conjugation, microchip compensation, FBG (Fiber Bragg Grating) etc are used to minimize the effect of dispersion [3].

The performance of 16 channels of WDM systems at 10 Gbps has been investigated using various hybrid and optical amplifiers. The result was evaluated on the basis of power level, eye pattern, BER measurement and Q-factor. RAMAN EDFA provides the best results in terms of output power (12.017 and 12.088) and least bit error rate ($10e^{-40}$ and $9.08 \times 10e^{-18}$) at 100 km [4]. Analysis for the employment of RZ super-Gaussian pulse inputs for various WDM systems like standard WDM, dense and extremist dense WDM systems, using dispersion compensating fibers (DCFs) has been done on WDM systems having a channel spacing of 25 GHz, 50 GHz, and 200 GHz respectively. The three different schemes for compensating the dispersion are performed in which Symmetric compensation scheme shows good result. The range of data rates for the WDM systems has been extended up to 40 Gbps for the DCF of length 10 km and single mode fiber of length 50 km and RZ Gaussian pulse is used in the system [5].

The Performance Comparison of Pre, Post and Symmetrical-Dispersion Compensation Techniques using DCF of 8 Channel WDM System at Gbps is analyzed. The three dispersion compensation techniques are compared in terms of BER, Q-factor and eye height in which symmetrical compensation shows better results than the pre and post compensation [6].

In this paper, research work is carried on the number of users that can be extended from 8 to 40 users. This paper is organized as follows. Section 2 describes the dispersion compensating fibers (DCF) and its types. Section 3 briefly discuss the model of 40 X 10 Gbps WDM-PON system. In Section 4, results are verified by using three compensation schemes. Finally, Section 5 concludes and summarizes the paper.

II. DISPERSION COMPENSATING FIBER (DCF)

The idea of victimization dispersion compensating fibers for dispersion compensation was proposed in 1980’s. The reason behind using the DCF in the WDM system is due to its inherent properties that are additionally stable, not simply lay down low with temperature and provides wide information. The DCF has become the foremost appropriate methodology for dispersion compensation. It is presently used because it eliminates the effects of dispersion in long-haul WDM networks. The utilization of DCF is done in properly and in an efficient manner to compensate the dispersion. DCF have higher negative dispersion coefficient so it can be connected to the fiber which has the positive coefficient of dispersion. Due to this, the resultant dispersion becomes zero in the link and dispersion is eliminated from the link.

The three different schemes of dispersion compensation on the basis of the position of the DCF are;

A. Pre-Compensation
B. Post- Compensation
C. Symmetrical-Compensation

A. The DCF is placed before the single mode fiber (SMF) in the pre-compensation scheme to compensate the dispersion.
B. The DCF is placed after the single mode fiber (SMF) in the post-compensation scheme to compensate the dispersion.
C. The Pre and post-compensation are used simultaneously in the symmetrical-compensation. In this, DCF is placed before as well as after the single mode fiber (SMF) to compensate the dispersion [7].

III. MODEL DESCRIPTION

The 40 Channel WDM-PON Network is designed using the Optisytem software version 7.0. The three different compensation schemes are used to compensate the dispersion at the data rate of 10 Gbps. FIGURE 1 shows the block diagram of the 40 X 10 Gbps WDM-PON system, which consists of the transmitter section, transmission medium, and the receiver section. At the transmitter side, WDM MUX is used to multiplex the signals. The output of all the 40 channels is multiplexed with the help of this WDM MUX and is transmitted through the transmission medium to WDM DEMUX. The transmission Channel has contained the SMF (Single Mode Fiber) of length 120 km and DCF of length 24 km. In pre and post-compensation schemes, 2 numbers of spans are taken so that the total link length become 288 km. But in a case of symmetric compensation, both the DCF of lengths 24 km and SMF of lengths 120 km are used twice in the system. Erbium-doped fiber amplifier (EDFA) is mainly used to amplify the signals in the transmitter.

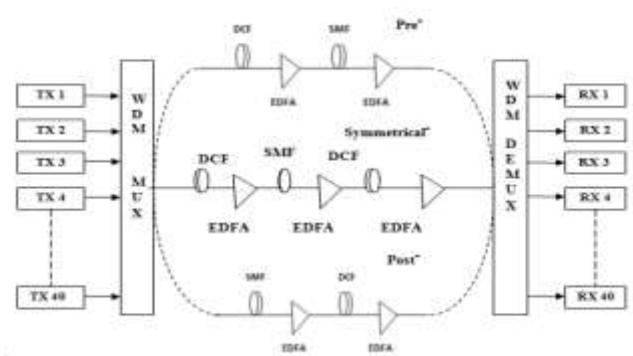


Fig. 1 Schematic block diagram of simulation setup for WDM-PON system based on different dispersion compensation techniques

A. Transmitter Section

The transmitter section mainly consists of CW laser array source used to a produce pseudo random sequence of bits at 10 Gbps data rate. The binary data is converted into electrical pulses with the help of NRZ pulse generator. Mach-Zehnder (M-Z) modulation scheme is preferred over the other modulation scheme which is used to modulate the signal. The block diagram of the transmitter section is shown in figure 2.

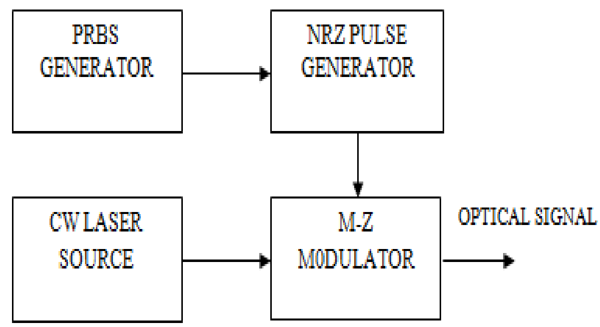


Fig. 2 Block diagram of the transmitter.

B. Receiver Section

At the receiver side, 1:40 WDM DEMUX is used to demultiplex the 40 channels and output of the demultiplexer is given to the pin photo detector and then passed to the low pass Bessel filter which used to remove the unwanted signals. The output of the low pass filter is passed to the regenerator which regenerates the original signal. The block diagram of the receiver section is shown in figure 3.

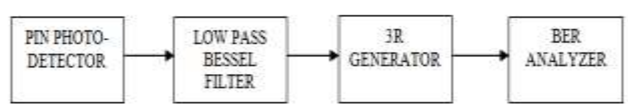


Fig. 3 Block diagram of the receiver section

All the parameters which are used in simulation work are presented in table 1 and table 2. Table 1 has contained the simulation parameters and Table 2 is showing the fiber parameters.

TABLE 1. Simulation Parameters

Parameters	Values
No. of Channels(users)	40
Bit rate	10 Gbps
Sequence length	64
Samples per bit	256
Central frequency of the first Channel	193.1 THz

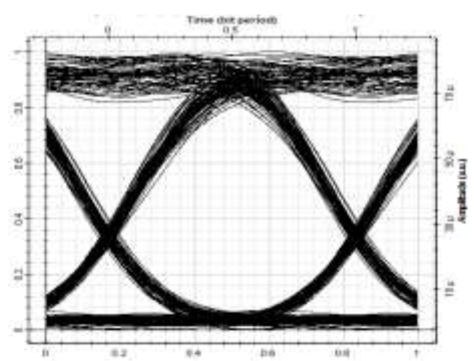
Channel Spacing	100 GHz
Channel Capacity	40 X 10 Gbps

TABLE 2. Fiber Parameters

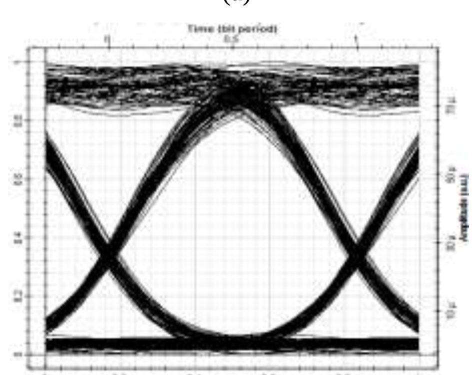
	SMF	DCF
Length (km)	120	24
Attenuation (db/km)	0.2	0.6
Dispersion (ps/nm/km)	17	-80
Dispersion Slope (ps/nm^2/km)	0.08	0.3
Different group delay (ps/km)	0.5	0.5

IV. RESULTS AND DISCUSSIONS

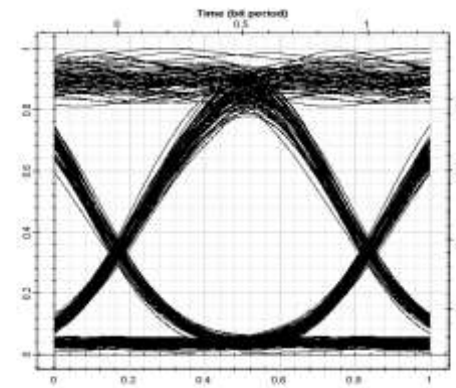
The performance of the 40 channels in WDM-PON system at 10 Gbps data rate is evaluated on the basis of BER and Q-factor. The different compensation techniques are used in the system to compensate the dispersion in order to achieve good quality factor and minimum BER. The eye pattern for pre, post, and symmetric compensation is shown in figures (4,5 and 6) and this eye pattern has been taken at 193.1 THz, 193.3 THz and 193.5 THz frequencies respectively. The values of BER and Q-factor are tabulated and compared in table 3 at different frequencies. The graphs for BER and Q-factor of three dispersion compensation schemes are shown in figure 7.



(a)

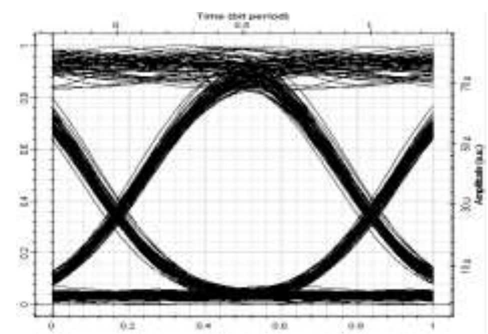


(b)

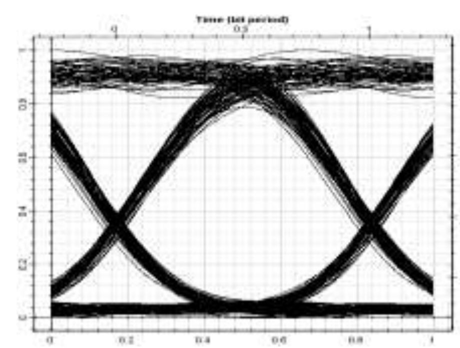


(c)

Fig. 4 Eye pattern of Pre-Compensation technique at (a) 193.1 THz (b) 193.3 THz and (c) 193.5 THz frequencies.



(a)



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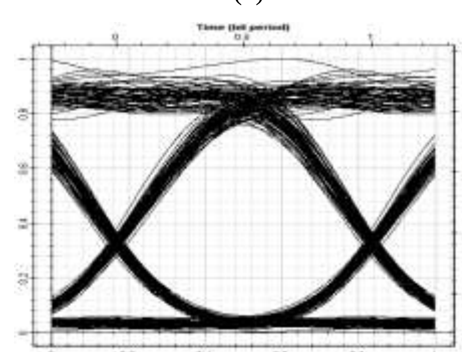
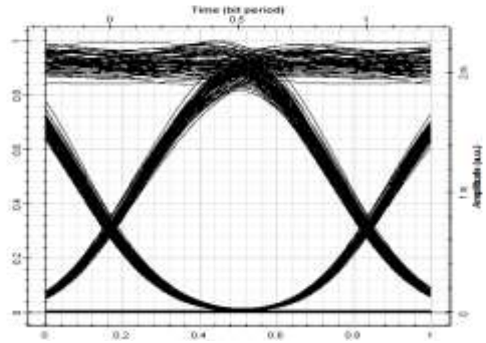
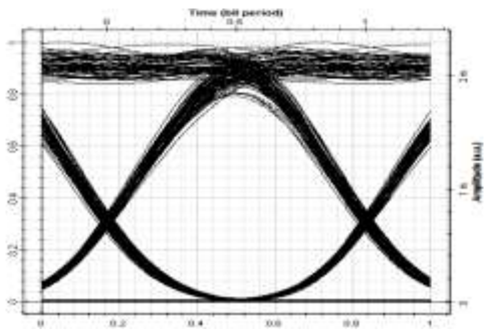


(c)

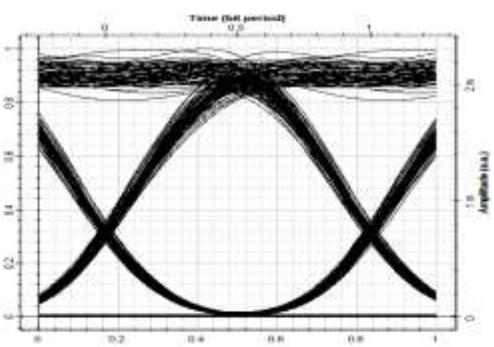
Fig. 5 Eye pattern of Post-Compensation technique at (a)193.1 THz (b) 193.3 THz and (c) 193.5 THz frequencies.



(a)



(b)



(c)

Fig. 6 Eye pattern of Symmetrical-Compensation technique at (a) 193.1 THz (b) 193.3 THz and (c) 193.5 THz frequencies.

TABLE 3. Comparison of three Compenstion Schemes at 193.1 THz, 193.3 THz and 193.5 THz

At 193.1 THz

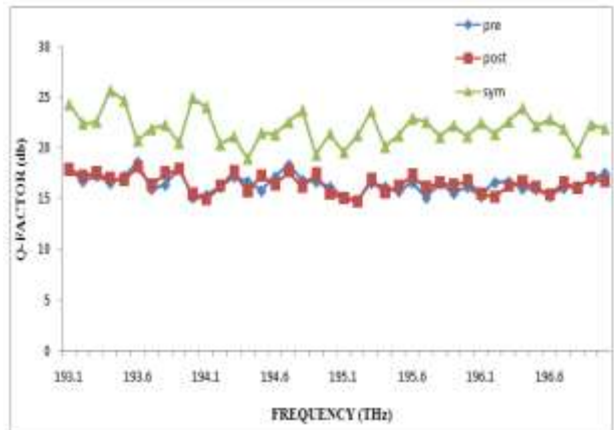
	Pre-Compensation	Post-Compensation	Symmetrical-Compensation
Quality Factor	17.88	17.81	24.33
BER	6.9211e-72	2.2769e-71	2.4489e-131

At 193.3 THz

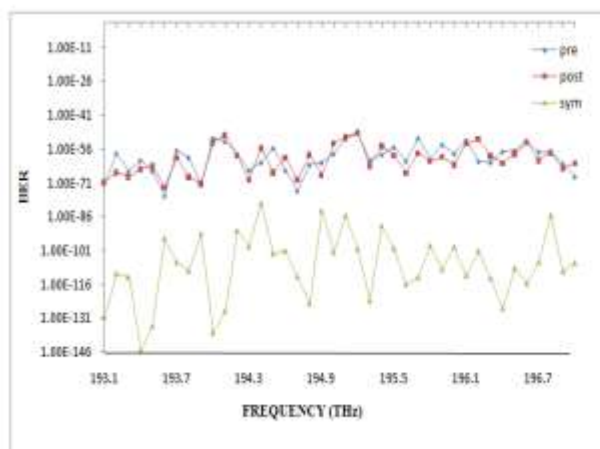
	Pre-Compensation	Post-Compensation	Symmetrical-Compensation
Quality Factor	17.21	17.50	22.59
BER	8.8283e-67	5.2502e-69	1.6034e-113

At 193.5 THz

	Pre-Compensation	Post-Compensation	Symmetrical-Compensation
Quality Factor	17.16	16.84	24.71
BER	2.118e-66	4.6153e-64	2.7270e-135



(a) Quality factor for 40 users at different frequencies.



(b) BER for 40 users at different frequencies.

Fig. 7 Graphs for Q-Factor Vs Frequency and BER Vs Frequency

V. CONCLUSION

In this paper, We have analyzed the performance of the 40 channels WDM-PON systems at 10 Gbps data rate on the basis of three compensation schemes to eliminate the effect of dispersion in the optical fiber links. SMF (Single Mode Fiber) of length 120 km and DCF (Dispersion Compensating Fiber) of 24 km are placed according to their position in the transmission medium. The BER and Q-factor are determined and compared on the basis of pre, post, and symmetrical compensation. From the results, it has been concluded that the symmetrical compensation technique shows better results than the pre and post compensation.

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