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Simulative Investigation and Comparison of 8 x 40 Gbps WDM system Using Different Dispersion Compensation Techniques Based On DCF

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Abstract

Wavelength division multiplexing (WDM) technology allows several channels to be routed through the same fiber cable with different wavelengths. In WDM systems dispersion , loss , attenuation , and non-linear effects are the issues that degrade its performance. Dispersion is a main limiting factor in high speed optical WDM system. In this paper 8 channel WDM system at 40Gbps and 125km length of optical fiber with 25 km length of DCF has been investigated for three dispersion compensation techniques i.e. pre , post and symmetric using DCF. All three methods are compared in terms of different parameters such as Q-factor, BER by using OptiSystem simulator .It has been observed that the set-up requires appropriate matching between EDFA gain and length of optical fiber for best performance.

Keywords: *Wavelength Division Multiplexing (WDM) , Dispersion compensating Fiber (DCF), Erbium Doped Fiber Amplifier(EDFA), BER , Q-factor*

1. Introduction

Fiber-Optical networks are high capacity networks that meet quickly increasing demand for bandwidth in the Telecommunication industry [1]. In order to extent the data carrying capability of an optical communication system WDM is one of the effective technique in optical communication system.WDM permit multiple wavelengths to be transmitted at same time over a single fiber [2].WDM support high bandwidth data transfer. The management of dispersion and non linearity's are main significance in WDM systems[3] The dominant aim of optical fiber communication is to expand the transmission distance [4]. The main factors that influence the WDM system are loss, dispersion , and non-linear effects like Self Phase Modulation (SPM) , cross phase modulation(XPM) and Four Wave Mixing (FWM) is observed at different data rates[5].So this dispersion and fiber non-linearity's effects at different data rates must be reduced by various dispersion compensation techniques like Fiber Bragg Grating (FBG)[6] Optical Phase Conjugation(OPC) [7] , Reverse Dispersion Fiber (RDF) [8] , Electronic Dispersion

Compensation [9] , Dispersion Compensating Fiber (DCF)[10].In order to reduce the impairments due to fiber non-linearity's optical amplifiers such as Erbium Doped Fiber Amplifier (EDFA),Raman amplifier, SOA are also used [11].The use of DCF is effective way to minimize the complete dispersion in WDM network as they have higher negative dispersion coefficient and can be attached to the transmission fiber having positive dispersion coefficient so that the complete dispersion of the link becomes zero.[12]. According to the comparative situation of DCF and single mode fiber, post-compensation,

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pre-compensation and symmetrical/mix compensation, is proposed [13].In this paper Q-factor and BER of 8 channel WDM system are analyzed over a distance of 125km of length of optical fiber and 25km length of DCF. This paper is divided into 4 sections, 1st section include introduction to WDM , 2nd section provides simulation set-up, 3rd section gives results and discussion and 4th section provides conclusion.

2. Simulation Set-up

The simulation set up for 8 channel WDM system is designed by using the Optisystem 7.0 simulator software. Three dispersion compensation techniques (Pre-, Post-, and symmetrical) are investigated and compared. During simulations the transmitter unit includes data source generate a pseudo random sequence of bits at 40 Gbps. Non-Return-Zero (NRZ) pulse generator transform the binary data into electrical pulses that modulates the optical signal across the Mach-Zehnder (M-Z) modulator. The block diagram of transmitter unit shown in Figure 1. There are 8 laser sources produces optical signals at different wavelengths. The channel spacing of 200 GHz is used with 1dbm output power.

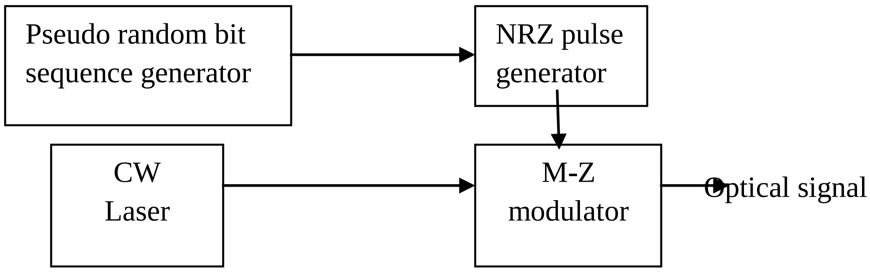


Figure 1. Block Diagram of Transmitter Unit

The multiplexer combines 8 input channels and transmit over a fiber optical channel. The transmission channel comprises of Single Mode Fiber (SMF) of length 125 km and DCF length of 25 km. The number of spans is taken to be two in pre-compensation and post compensation technique , So the total link length is 300 km . In symmetrical compensation technique only one span is used.2 SMFs each of length 125km and 2 DCFs each of length 25 km is used , so that the total length of link is 300 km. in all three compensation techniques. Two EDFA in front of transmission fiber with gain 25 and DCF with gain 15 and 4dB noise figures each are used to adjust the input power levels. EDFA are used in the system to amplify the optical signals.

The receiver unit comprises of demultiplexer , PIN photo detector , low pass filter and 3R regenerator.1:8 demultiplexer is used to splits the signals to 8 different channels. the output of demultiplexer is given to photo detector and then passes through Low Pass Bessel filter and 3R regenerator. The block diagram of receiver unit is shown in Figure 2.

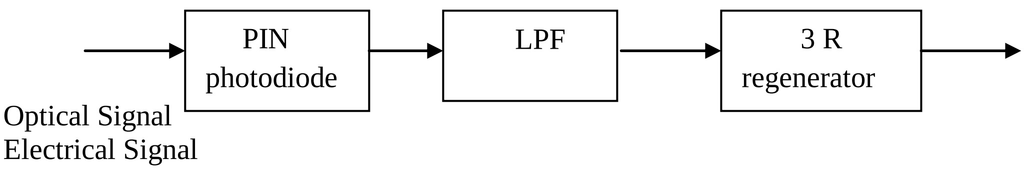


Figure 2. Block Diagram of Receiver Unit

Table 1. Simulations Parameters

Parameters	Value
Bit rate	40 Gbps
Capacity	8x40 Gbps
Central frequency of first channel (THz)	192.3 THz
Channel spacing (GHz)	200

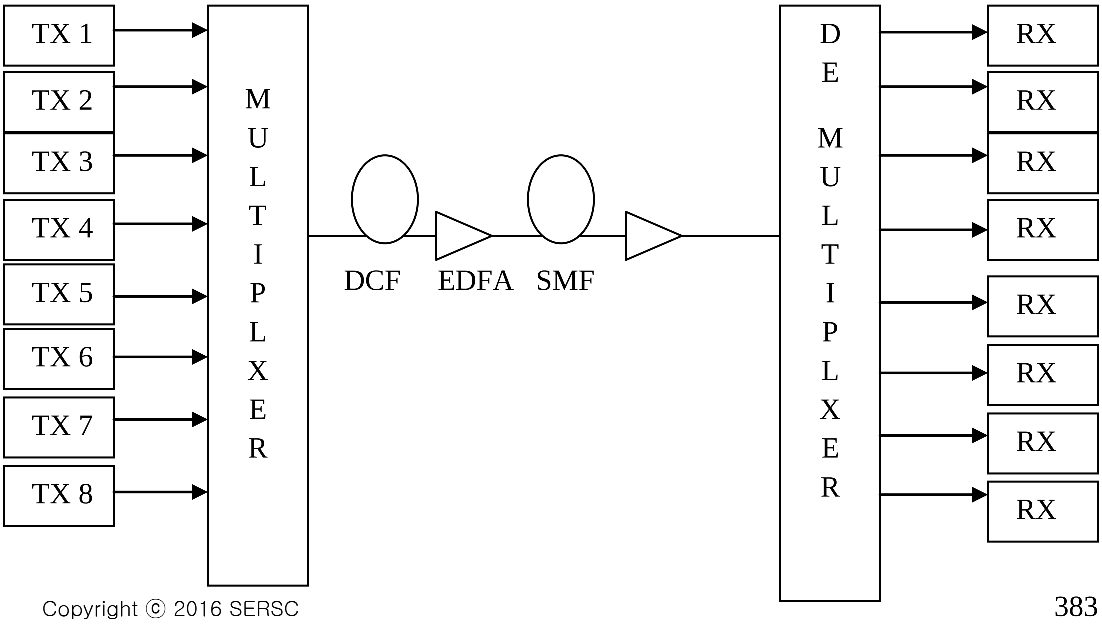
Table 1. Shows that the Required Parameters use in Different Dispersion Compensation Techniques in 8 x 40 Gbps WDM System sing DCF.

Table 2. Fiber Parameters

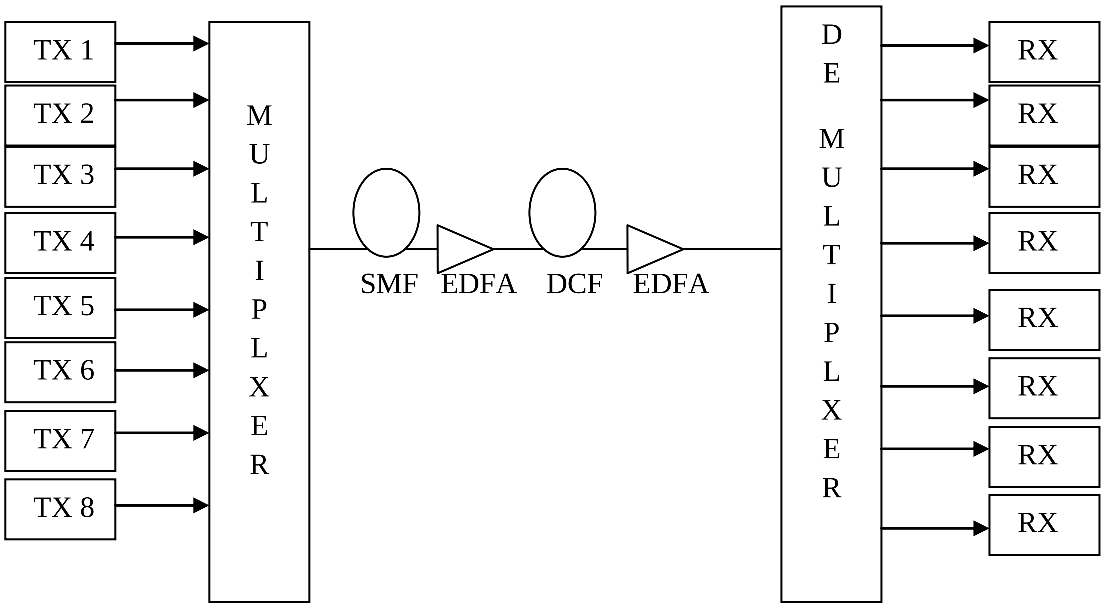
Parameters	SMF	DCF
Length(km)	125	25
Dispersion(ps/nm/km)	17	-85
Dispersion slope(ps/nm^2/km)	0.08	0.3
Attenuation(db/km)	0.2	0.6
Differential group delay(ps/nm)	0.5	0.5
PMD coefficient(ps/km)	0.5	0.5

Table 2. Shows the Required Fiber Parameters used in Different Dispersion Compensation Techniques

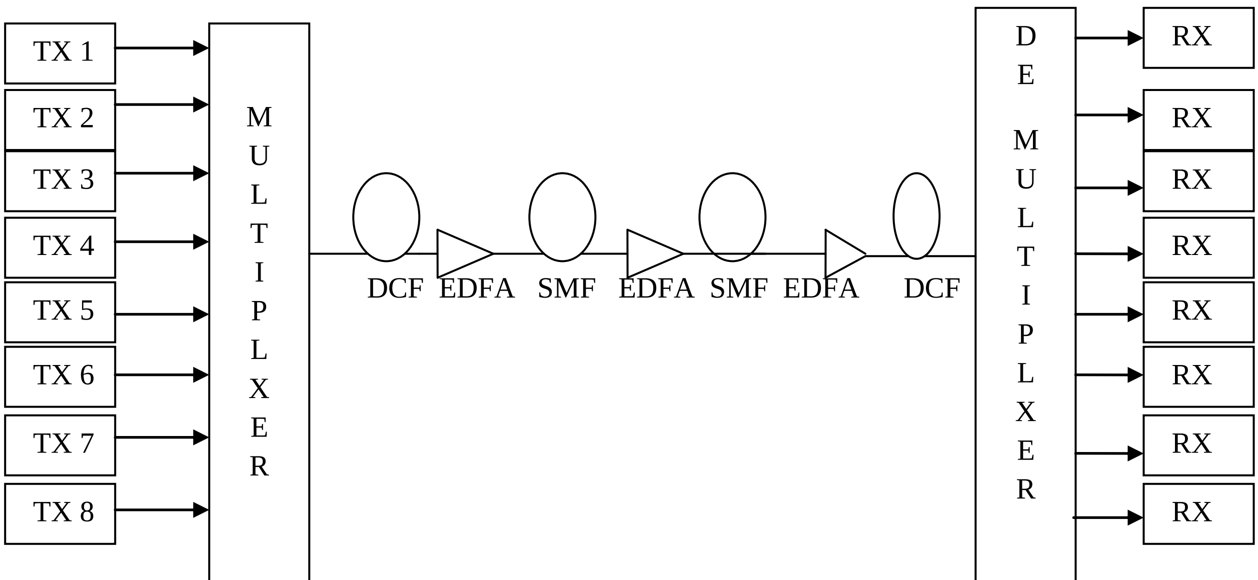
The simulation setup of three dispersion compensating techniques are shown in Figure 3. In Pre-Compensation Technique DCF is placed before SMF to compensate the dispersion in the standard fiber. In Post-Compensation Technique DCF is placed after the SMF to compensate the dispersion in the standard fiber. In Symertrical-Compensation/mix-compensation Technique DCF is placed before and after the SMF to compensate the dispersion in the standard fiber.



(a) Pre-Compensation Technique.



(b) Post-Compensation Technique.

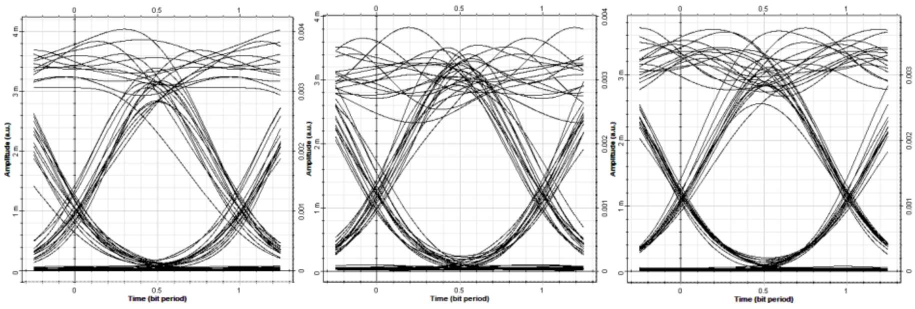


(c) Symmetric-Compensation Technique.

Figure 3. Simulation Set-up for WDM System Based on Different Dispersion Compensation Techniques

3. Results and Discussions

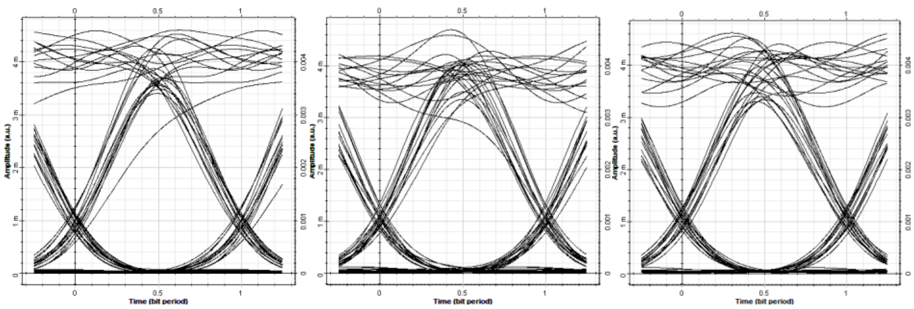
The three different dispersion compensation techniques i.e. Pre-compensation technique , Post – Compensation technique, Symertrical-compensation/mix compensation technique has been analysed at 40Gbps for 8 channel WDM optical system in terms of Bit Error Rate (BER) and Q-factor.



(a) (b) (c)

Figure 4: Eye-Diagram of (a) Pre-Compensation (b) Post-Compensation and (c) Symmetrical-Compensation at First Channel (192.3 THz)

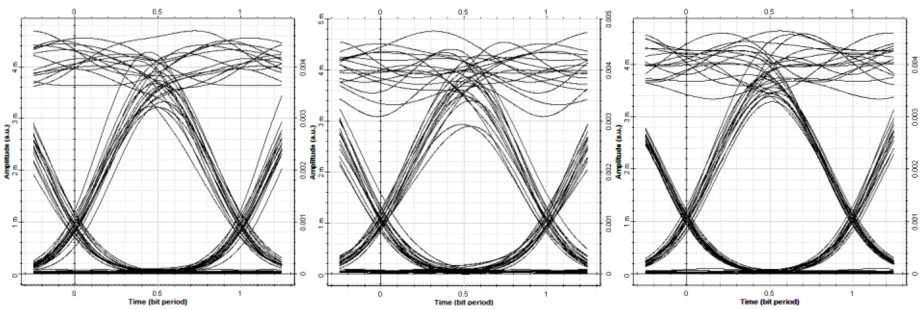
Figure 4 shows the Eye diagram of Pre-compensation, Post-compensation and , Symmetrical-compensation at first channel (192.3 THz). Pre-compensation technique provides the Q-factor 6.99841 and BER 4.09011e-014. Post-compensation technique provides the Q-factor 8.72187 and BER 5.75398e-018. Symmetrical-compensation technique provides the Q-factor 10.0276 and BER 4.21742e-024.



(a) (b) (c)

Figure 5. Eye-Diagram of (a) Pre-Compensation (b) Post-Compensation and (c) Symmetrical-Compensation at Fourth Channel (192.9 THz)

Figure 5 shows the Eye diagram pre-compensation , post-compensation and symmetrical-compensation at fourth channel (192.9 THz).Pre-compensation technique provides Q-factor 8.31765 and BER 2.3763e-017. Post-compensation technique provides Q-factor 9.29049 and BER 7.35841e-021. Symmetrical-compensation technique provides Q-factor 11.6028 and BER 1.17065e-030.



(a) (b) (c)

Figure 6. Eye-Diagram of (a) Pre-Compensation (b) Post-Compensation and(c) Symmetrical-Compensation at Eighth Channel (193.7 THz)

Figure 6 : Eye-diagram of pre-compensation , post-compensation and symmetrical-compensation at Eighth channel (193.7 THz). Pre-compensation technique provides the Q-factor 10.3807 and BER 7.36002e-016. Post-compensation technique provides the Q-factor 9.03481 and BER 6.03462e-020. Symmetrical-compensation technique provides the Q-factor 10.6148 and BER 6.75006e-026.

Table 3. Comparison of Three Dispersion Compensating Techniques on the Basis of Q-Factor for 8 Channel WDM System

Freq. (THz)	Q-Factor		
	Pre compensation	Post Compensation	Symmetric compensation
192.3	6.99841	8.72187	10.0276
192.5	7.05509	9.53931	9.85681
192.7	8.58912	7.96342	13.7926
192.9	8.31765	9.29049	11.6028
193.1	7.66439	9.19711	13.6353
193.3	10.8371	8.79259	17.2315
193.5	11.7209	10.6194	13.2331
193.7	10.3807	9.03481	10.6148

Table 3 Shows that Q-Factor of the Symmetric Compensation Technique is Better as Compared to the Pre Compensation and Post Compensation Technique for 8 Channel WDM System

Table 4. Comparison of Three Dispersion Compensating Techniques on the Basis of BER for 8 Channel WDM System

Freq.(THz)	BER		
	Pre compensation	Post Compensation	Symmetric Compensation
192.3	4.09011e-014	5.75398e-018	4.21742e-024
192.5	5.14125e-013	4.62211e-021	1.63608e-022
192.7	2.38585e-018	4.94465e-016	7.64413e-034
192.9	2.3763e-017	7.35841e-021	1.17065e-030
193.1	4.79291e-015	1.09109e-020	7.30388e-032
193.3	1.09173e-028	4.07441e-019	4.29225e-035
193.5	2.62729e-027	7.8507e-027	1.9505e-036
193.7	7.36002e-016	6.03462e-020	6.75006e-026

Table 4. Shows that BER of Symmetric Compensation Technique is Better as Compared to the Pre-Compensation and Post Compensation for 8 Channel WDM System.

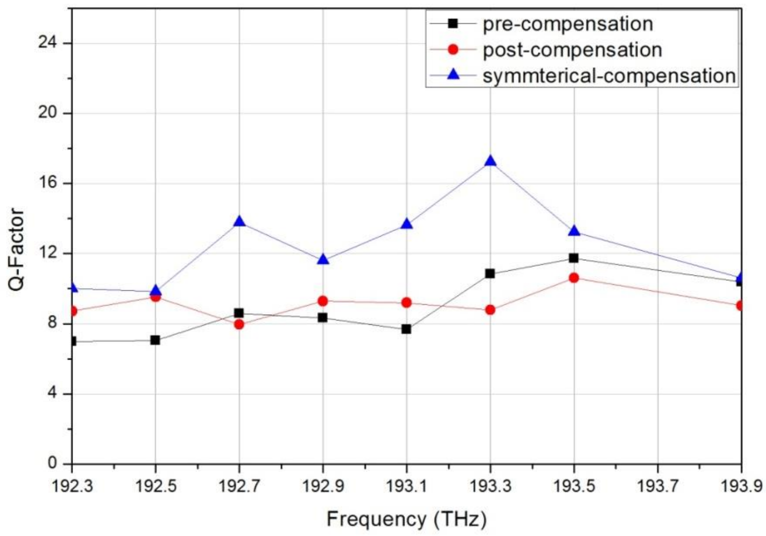


Figure 7. Comparision Graph of Three Dispersion Compensation Techniques in Terms of Q-Factor for 8 Channel WDM System.

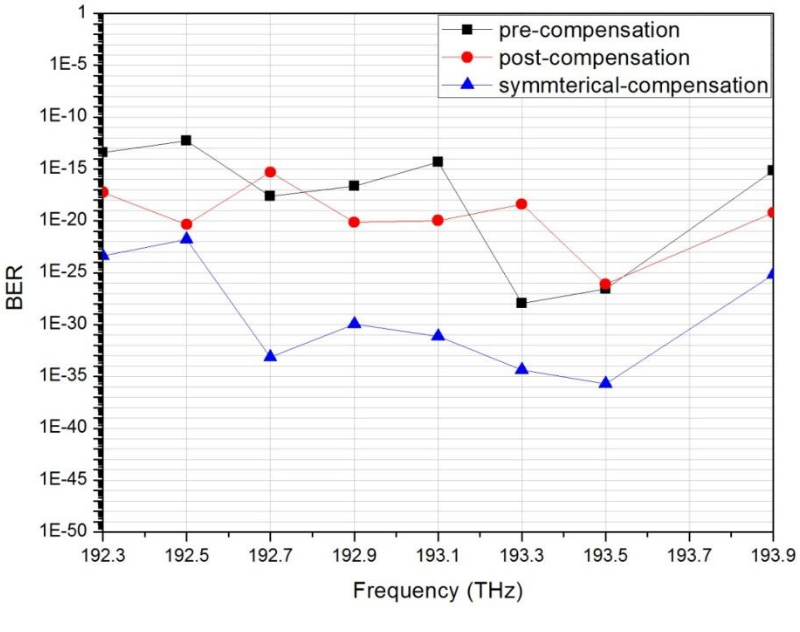


Figure 8. Comparision Graph of Three Dispersion Compensation Techniques in Terms of BER for 8 Channel WDM System.

4. Conclusion

One of the most extreme impairments that limit the performance in long distance and high speed optical transmission systems is dispersion.Dispersion introduces Inter Symbol Interference that degrade the information carrying capacity of fiber. In this investigation , the 8 channel WDM system at 40 Gbps with different dispersion compensating techniques based on DCF has been investigated.The three dispersion compensation techniques using DCF (pre-,post-and symmetric compensation) are compared in terms of Q-factor and BER .The simulations results shows that the symmetrical compensation technique is better than pre-compensation and post-compensation techniques for 8x40 Gbps WDM system.

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