Volume 6, Issue 4, April 2016 ISSN: 2277 128X
International Journal of Advanced Research in Computer Science and Software Engineering
Research Paper
Available online at: www.ijarcsse.com

Simulative Investigation and Comparison of 32 x 40 Gbps DWDM System Using Different Dispersion Compensation Techniques Based on DCF

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Abstract: One of vital problems in telecommunication industry is enormous demand for bandwidth and data rate. Dense Wavelength Division Multiplexing (DWDM) technology allows several channels to be routed through the same fiber cable with different wavelengths .DWDM technology meet the growing demands for bandwidth and data rate. The significant problem that DWDM technique experience is Dispersion which results in deterioration of system performance and expand the light pulses. In this paper different dispersion compensation techniques such as pre-compensation , post-compensation and symmetrical compensation using Dispersion Compensating Fiber (DCF) for 32 channels DWDM system at 40 Gbps has been investigated. The DWDM system has been analyzed and compared in terms of Q-factor and Bit Error Rate(BER) by using OptiSystem simulator. The Simulation results shows that the symmetrical-dispersion compensating technique is better than other dispersion compensating techniques using DCF.

Keywords: Dense Wavelength Division Multiplexing (DWDM), Erbium Doped Fiber Amplifier (EDFA), Dispersion Compensating Fiber (DCF) , BER ,Q-factor.

I. INTRODUCTION

With the development of optical fiber technology in communication , increasing requirement for higher capacity and transmission over extended distance is upgrade. DWDM is best technology to satisfy this demand[1].DWDM is a fiber optic technology that transmit multiple data streams simultaneously over a single fiber[2]. For DWDM system in which data rate is > 10 Gbps per channel, the adverse effect of dispersion and nonlinearty should be managed to attain transmission over a considerable distance[3]. This technology has many characteristics such as huge bandwidth, reliable performance, massive transmission capacity , and compatibility with the current communication system[4].The major constraints in development of DWDM system are degradation of signal due to losses , dispersion and non-linear effects, Cross Phase Modulation(XPM) , Self Phase Modulation (SPM) and Four Wave Mixing (FWM).When a optical signal undergoes a longer distance , the dispersion effect can cause a unacceptable amount of distortion that eventually leads to degrade system performance[5][6][7].So , it necessary to compensate the dispersion by using different compensating techniques such as Optical Phase Conjugation(OPC)[8] , Fiber Bragg Grating (FBG) [9] , Electronic Dispersion Compensation (EDC) [10], Reverse Dispersion Fiber (RDF) [11] and Dispersion Compensating Fiber (DCF) [12]. The impairments because of fiber non-linearities can be minimized by using different amplifiers like Erbium Doped Fiber Amplifier (EDFA) , SOA , and Raman amplifier[13].Dispersion Compensating Fiber (DCF) are used to decrease the overall dispersion in the optical link as DCF have higher negative dispersion coefficient and can be attached to single mode fiber(SMF) having positive dispersion coefficient[14]. Based on the location of DCF, the compensation techniques can be pre-compensation, post compensation and symmetrical compensation[15].

II. SIMULATION SETUP

The 32 x 40 Gbps DWDM system is designed and simulated using Optisystem simulator software. The transmitter part comprises of 32 channels that have equally spaced emission frequency range from 191-194.1 THz , i.e. channel spacing is 100 GHz. Each transmitter part comprises of data source which generate the Pseudo random sequence of bits at data rate of 40 Gbps.NRZ pulse generator translate the binary data into electrical pulse that modulates the laser signal via. Mach-Zehnder (M-Z) Modulator.

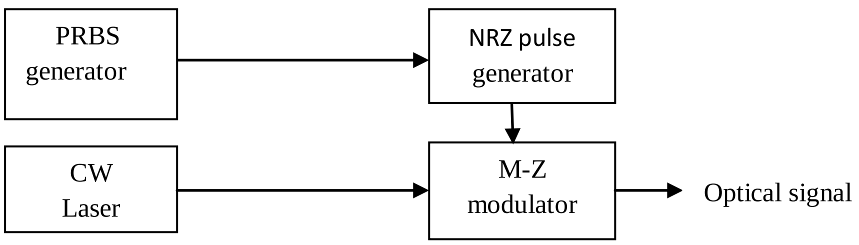


Figure 1: Block diagram of Transmitter part.

The Multiplexer combines the 32 input channels and transmit over the single fiber link. The transmission channel comprises of Single Mode Fiber (SMF) of length 80 km and DCF length of 16 km. The number of spans is taken to be two in pre-compensation and post compensation technique , So the total link length is 192 km . In symmetrical compensation technique only one span is used .2 SMFs each of length 80 km and 2 DCFs each of length 16 km is used, so that the total length of link is192 km in all three compensation techniques. Two EDFA in front of transmission fiber with gain 15 and DCF with gain 5 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 part comprises of demultiplexer, PIN photo detector, low pass filter and 3R regenerator.1:32 demultiplexer is used to splits the signals to 32 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 part is shown in Figure 2.

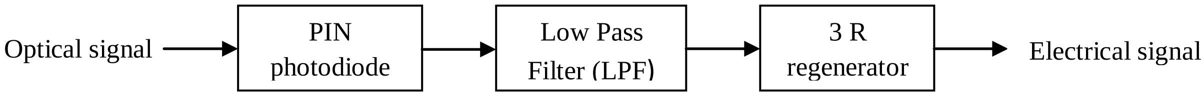


Figure 2: Block Diagram of Receiver part.

Table 1: Simulations parameters for 32 channel DWDM system

Parameters	Values
Bit rate	40 Gbps
Sequence length	64
Samples per bit	256
Central frequency of first channel	191 THz
Channel Spacing	100 GHz
Capacity	32 x 40 Gbps

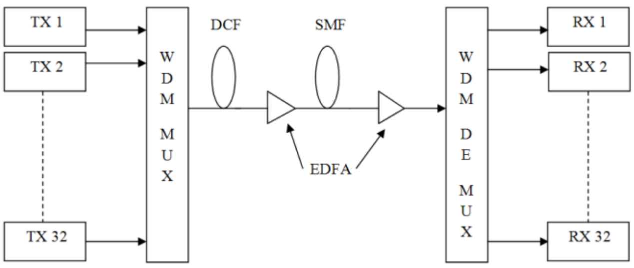
Table 1: shows that the required parameters use in different dispersion compensation techniques in 32 x 40 Gbps DWDM system using DCF.

Table 2: Fiber Parameters

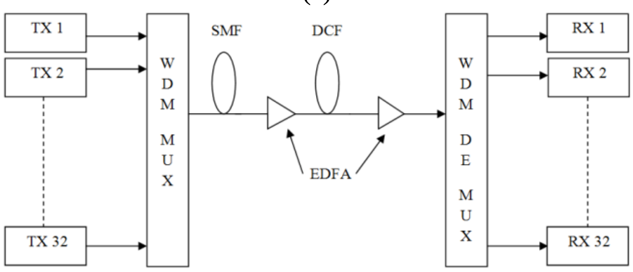
Parameters	SMF	DCF
Length	80	16
Attenuation	0.2	0.6
Dispersion(ps/nm/km)	17	-85
Dispersion slope(ps/nm^2/km)	0.08	0.3
Differential group delay(ps/nm)	0.5	0.5
PMD coefficient(ps/km)	0.5	0.5

Table 2: Shows the required fiber parameters used in different dispersion compensation techniques.

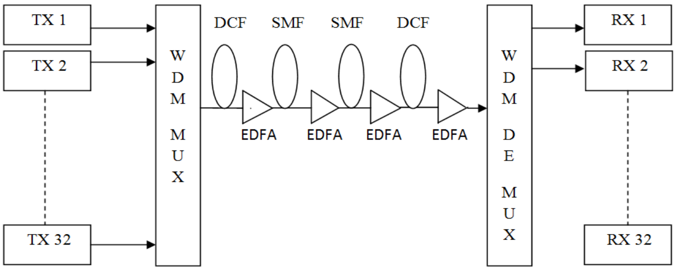
The simulation setup of three dispersion compensating techniques are shown in Figure 3. In Pre-Compensation Technique DCF is placed before SMF to compensate the dispersion in the standard fiber. In Post-Compensation Technique DCF is placed after the SMF to compensate the dispersion in the standard fiber.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



(a)



(b)

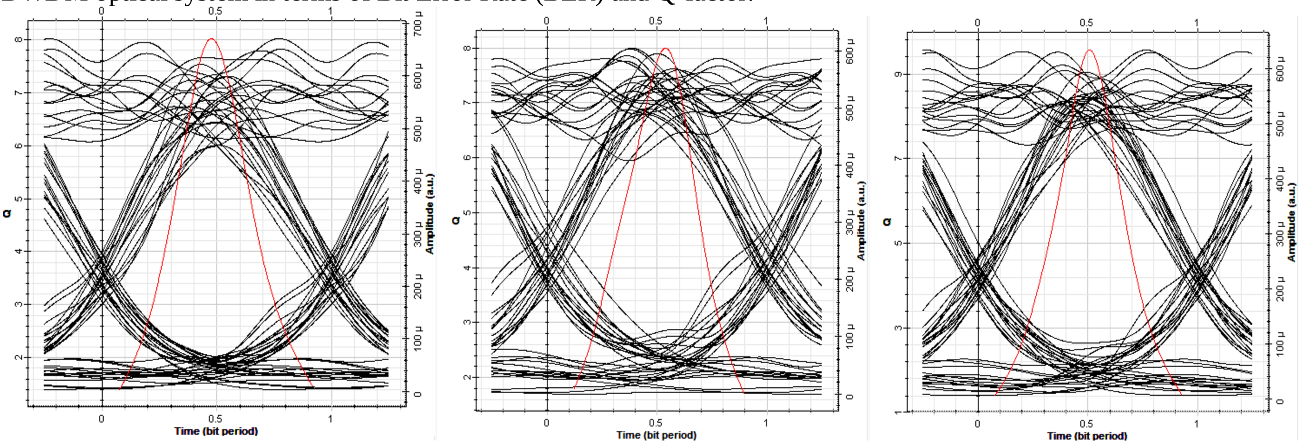


(c)

Figure 3: Simulation setup of (a) Pre-Compensation Technique (b) Post-Compensation Technique (c) Symmetric-Compensation Technique of DWDM system based on different dispersion compensation techniques.

III. RESULTS AND DISCUSSIONS

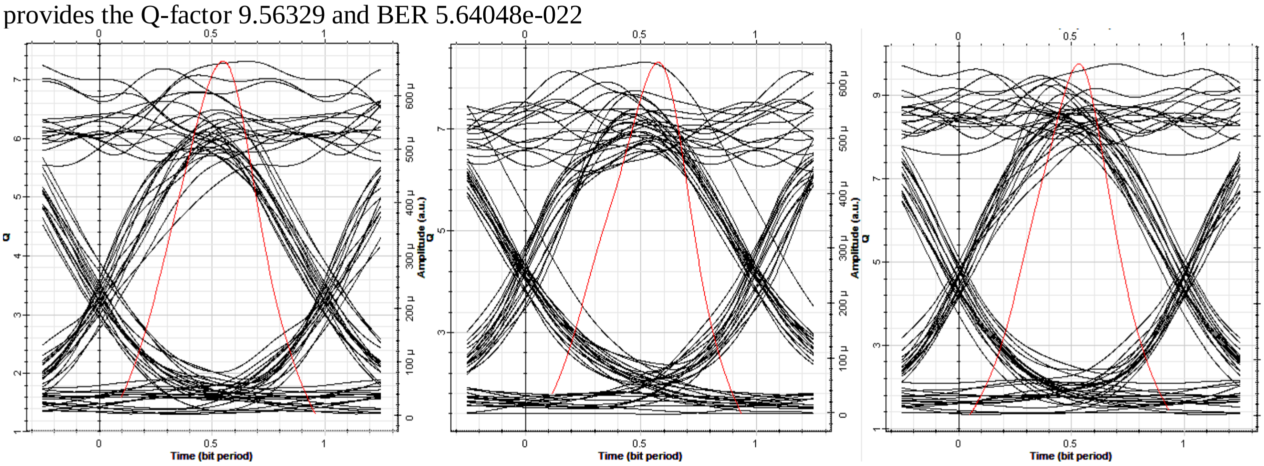
The three different dispersion compensation techniques i.e. Pre-compensation technique , Post – Compensation technique, Symmertrical-compensation/mix compensation technique has been analysed at 40Gbps for 32 channel DWDM optical system in terms of Bit Error Rate (BER) and Q-factor.



(a) (b) (c)

Figure 4: Eye-diagram of (a) Pre-compensation (b) Post-compensation and (c) Symmetrical-compensation at sixth channel (191.5 THz).

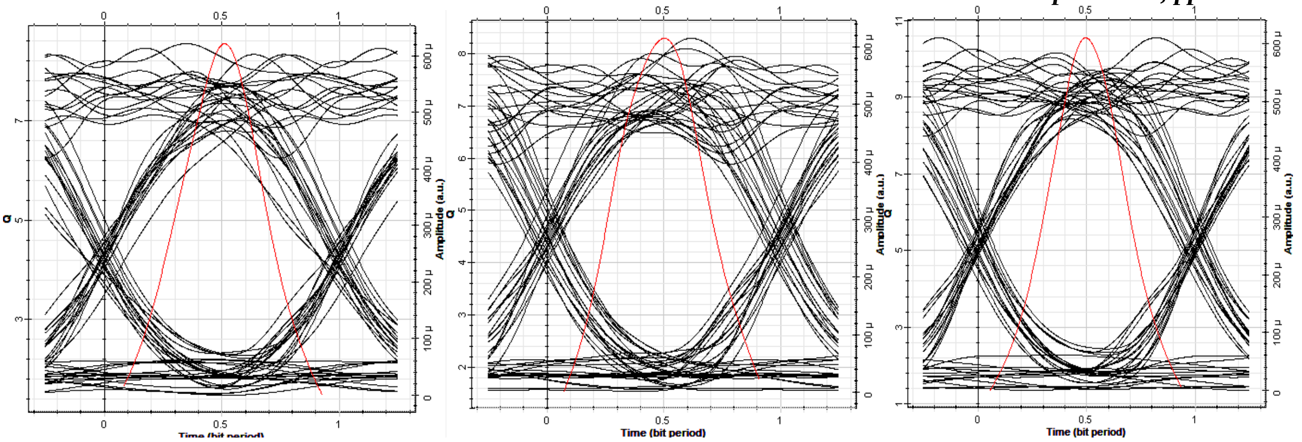
Figure 4 shows the Eye diagram of Pre-compensation, Post-compensation and , Symmetrical-compensation at sixth channel (191.5 THz). Pre-compensation technique provides the Q-factor 8.01436 and BER 4.73567e-016. Post-compensation technique provides the Q-factor 7.99293 and BER 6.54727e-015. Symmetrical-compensation technique provides the Q-factor 9.56329 and BER 5.64048e-022



(a) (b) (c)

Figure 5: Eye-diagram of (a) pre-compensation (b) post-compensation and (c) symmetrical-compensation at fourteen channel (192.3 THz).

Figure 5 shows the Eye diagram pre-compensation, post-compensation and symmetrical-compensation at fourteen channel (192.3 THz).Pre-compensation technique provides Q-factor 7.30573 and BER 1.23566e-013. Post-compensation technique provides Q-factor 8.31334 and BER 4.51119e-017. Symmetrical-compensation technique provides Q-factor 9.76049 and BER 8.814109e-023.



(a) (b) (c)

Figure 6: Eye-diagram of (a) pre-compensation (b) post-compensation and(c) symmetrical-compensation at twenty sixth channel (193.5 THz).

Figure 6 : Eye-diagram of pre-compensation , post-compensation and symmetrical-compensation at twenty sixth channel (193.5 THz). Pre-compensation technique provides the Q-factor 8.5471 and BER 6.02389e-018. Post-compensation technique provides the Q-factor 8.09114 and BER 5.26599e-017. Symmetrical-compensation technique provides the Q-factor 10.5457and BER 2.67049e-026.

Table 3: Comparison of three dispersion compensating techniques on the basis of Q-factor for 32 channel DWDM system.

Frequency (THz)	Q-factor		
	Pre-compensation	Post-compensation	Symmetrical -compensation
191	9.59638	9.62841	9.92863
191.1	7.89761	7.44256	8.35905
191.2	7.74344	7.32425	8.06823
191.3	7.79364	8.14112	9.07736
191.4	7.70332	7.34238	8.10334
191.5	8.01436	7.99293	9.56329
191.6	7.11682	7.50062	7.96331
191.7	7.43993	8.36614	9.7903
191.8	8.84444	7.40033	8.93945
191.9	8.03043	8.24024	8.47206
192	7.98596	8.71474	9.27587
192.1	9.09181	8.31837	12.4936
192.2	7.33436	7.66699	9.34193
192.3	7.30573	8.31334	9.76049
192.4	8.89311	8.79337	9.67209
192.5	10.0628	7.63081	10.61252
192.6	7.84858	8.75329	9.01037
192.7	7.73086	9.30541	10.21621
192.8	8.64476	9.61727	11.54153
192.9	8.15386	8.37596	9.85094
193	10.0671	8.91462	11.99261
193.1	7.59059	9.49461	11.20877
193.2	8.63537	9.23327	9.30464
193.3	7.07327	9.63658	9.79963
193.4	9.23033	9.97559	10.91793
193.5	8.5471	8.09114	10.5457
193.6	9.07005	8.31602	9.27824
193.7	8.50462	8.23185	9.65209
193.8	8.65269	7.03024	9.31144
193.9	9.10737	8.03454	9.844467
194	8.37289	9.35581	9.75443
194.1	8.83034	8.70347	10.3519

Table 3 shows that Q-factor of the symmetrical compensation technique is better as compared to the pre compensation and post compensation technique for 32 channel DWDM system.

Table 4: Comparison of three dispersion compensating techniques on the basis of BER for 32 channel DWDM system.

Frequency (THz)	BER		
	Pre-compensation	Post-compensation	Symmetrical-compensation
191	4.08254E-22	7.94006E-21	1.55795E-23
191.1	1.33772E-15	4.89483E-14	3.1424E-16
191.2	4.5928E-15	1.1522E-13	3.50669E-16
191.3	3.1809E-15	1.8634E-12	7.2458E-18
191.4	6.65559E-15	9.33513E-14	2.6502E-16
191.5	4.73567E-16	6.54727E-15	5.64048E-22
191.6	5.12499E-13	3.1023E-14	8.14222E-16
191.7	4.59194E-14	2.8586E-17	5.51997E-23
191.8	4.20997E-19	6.11572E-14	1.89823E-20
191.9	4.48362E-16	7.62106E-16	1.14509E-17
192	6.7087E-16	1.39061E-18	8.52863E-21
192.1	7.24044E-20	4.27407E-17	8.3496E-30
192.2	1.101628E-13	8.60031E-15	4.69597E-21
192.3	1.23566E-13	4.51119E-17	8.814109E-23
192.4	2.54339E-19	7.0059E-19	1.873E-22
192.5	3.5454E-24	9.87938E-15	1.23774E-26
192.6	1.90976E-15	9.05914E-19	9.73922E-20
192.7	4.83339E-15	6.40278E-21	9.19465E-24
192.8	2.49223E-18	3.11918E-22	3.82319E-31
192.9	1.5803E-16	2.65693E-17	3.19995E-23
193	3.587E-24	2.29697E-19	1.90197E-25
193.1	1.41019E-14	2.29697E-19	4.73794E-29
193.2	2.77262E-18	1.22117E-20	6.72345E-21
193.3	7.42341E-13	2.7945E-22	5.42393E-23
193.4	1.29041E-20	9.42745E-24	1.25095E-25
193.5	6.0289E-18	5.26599E-17	2.67049E-26
193.6	5.57999E-20	9.463331E-17	8.25553E-21
193.7	8.47471E-18	8.82749E-17	2.28679E-22
193.8	2.28857E-18	1.28166E-15	5.7943E-21
193.9	1.14323E-20	6.9884E-16	3.35587E-23
194	2.60788E-17	1.39293E-15	9.99411E-19
194.1	4.88047E-19	1.54459E-18	1.94366E-25

Table 4 shows that BER of symmetrical compensation technique is better as compared to the pre-compensation and post compensation for 32 channel DWDM system.

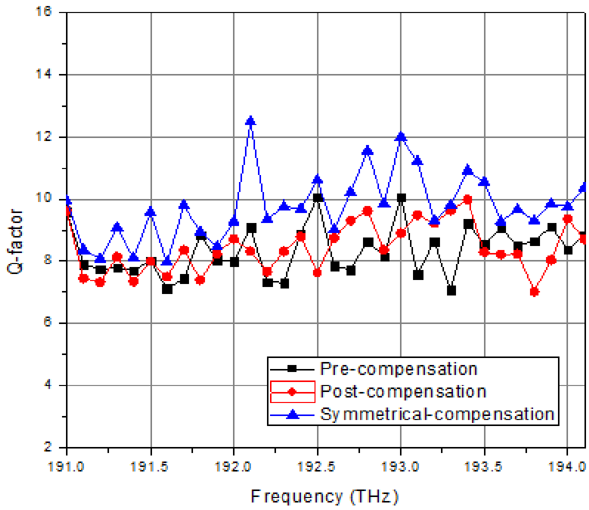


Figure 7: Comparision graph of three dispersion compensation techniques in terms of Q-factor for 32 channel DWDM system.

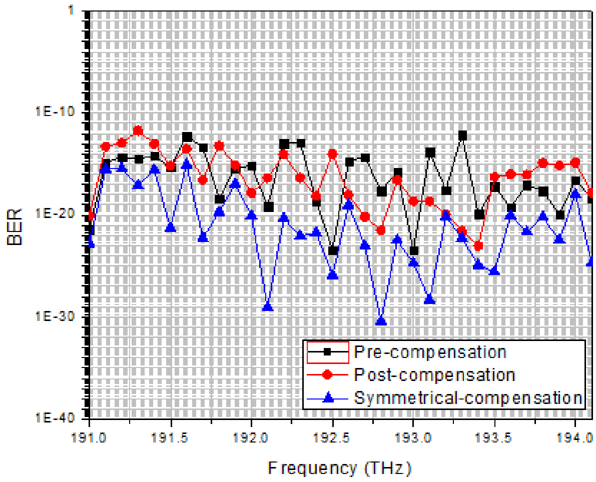


Figure 8: Comparision graph of three dispersion compensation techniques in terms of BER for 32 channel DWDM system.

IV. CONCLUSION

Dispersion is a main obstacle that hinder the performance in long distance and high speed optical transmission system.In this investigation , the 32 channel DWDM 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 symmetrical 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 32x40 Gbps DWDM system.

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