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Dispersion Compensationin Optical Fiber Communication System Using WDMwith DCFand FBG

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Abstract: *Dispersion compensation in optical fiber communication system is analyzed. Performance is analyzed at10 Gbps in optical communication system with different transmission distance.To analyze the different modulation formats for optical modulation system and the impact of dispersion compensators on the performance of efficient optical communication system.Q factor and BER is analyzed with respect to length of fiber.Dispersion compensation fiber and Fiber Brag Grating are used in this paper;we analyzed the three different compensation techniques pre,post and symmetric compensation. It has been seen that symmetric compensation scheme is best as compared to pre and post.*
Keywords: *Dispersion compensation,Fiber brag grating,EDFA,BER,DCF,wavelength division multiplexing*

I. Introduction

We use DCF for enhancing the system utility.Three techniques (Pre-compensation, post-compensation, mix-compensation of at a rate of 10 Gb/s with NRZ modulation format with DCF and FBG provide highdata rate in optical transmission. .The demand for transmission capability and bandwidth become more challenging in information Industry.For increasing transmission distance it is necessary to investigate the transmission characteristics. Loss and dispersion reduce the system capacity somore capacity is required due to rapid growth in the number of internet users. EDFA works in 1550 nm wave band to fulfill the needs of high speed, high bandwidth and high capacity networks WDM system has introduce in the optical fiber communication.WDM networks have ability to transmit multiple signals having different wavelengths simultaneously (1).In these networks different signals from different users having different wavelengths are multiplexed.Optical fiber used may be multimode fiber or Single Mode Fiber (SMF) depending upon its use. In this paper, we use Single Mode Fiber (SMF) because it has less distortion. At the transmitter Pseudo random bit sequence generator with NRZ Encoder and Continuous Wave to get the appropriate input to the 8: 1 multiplexer LASER and Mach-Zehnder is used. Here 8: 1 Multiplexer is used for all 8- Channels. At the receiver PIN diode used as a photodetector with low pass Bessel filter.First focuses on the NRZ modulation format used to create the optical pulseswe have to increase the speed of transmission especially latency and throughput between a transmitter and receiver. We have considered the performance control analysis of single mode optical fiber. Due to less dispersion, single mode fiber is used.At last to simulate the operationOpti-system software is used.The implementation of WDM would not have been possible without the development of EDFAs. Because these amplifiers operate close to the 1550nm wavelength range, they are compatible with optical fibers that also operate in the same 1550nm wavelength window. As a Network is set up in university campuses, office buildings, industrial plants, so, we have to increase the speed of transmission specially latency and throughput between a transmitter and receiver. The acceptable limit of crosstalk is -30dB(2).

II. Dispersion Compensation Fiber

Dispersion effectsfor both digital and analog transmission along optical fiber.Wavelength division multiplexing (WDM) technology used in dispersion fiber communicationswhich combine a number of optical carrier signals into a single optical fiber by using different wavelengths. WDM techniques enhance the capacity and provide bidirectional communication.Fiber brag grating is used for blocking certain wavelength and passed wavelength having same phase.When the signal is transmitted into the fiber, the distortion occurs due to dispersion and nonlinear effects of the fiber. So the distorted signal must be done to maintain the original signal. In order To minimize the signal distortion, the fibers must have opposite dispersion values. So we are applying this topology so that dispersion can be eliminated sufficiently(3).

A Bessel filter is an analog linear filter with maximum linear phase response. This filter is same as Bessel– Thomson filters.When increasing the filter order it tends towards the shape of Gaussian filter.DCF for dispersion compensation was proposed in 1980 but when optical amplifiers are invented DCF helps to reduce the dispersion.SMF have positive dispersion and DCF have negative dispersion so overall dispersion is zero(4).Conventional dispersion compensating fibers have a high negative dispersion -80 ps/nm.km and can be used to compensate the positive dispersion oftransmission fiber in C-band. According to the position of DCF

Three compensation scheme is proposed. In precompensation scheme DCF is placed before the SMF and post compensation Scheme DCFis placed after the single mode fiber and in symmetrical compensation scheme DCF is placed before and after the SMF (4).

Length of fiber depends upon the signal power, pump power and pump wavelength. Fig shows that input signal having wavelength 1550nm and the diode laser signal combined with wavelength multiplexer. This signal passes through the EDFA interact with Er+3 ions and get amplified and the output we get amplified signal WDM in which multiple signals are get combine and send over a Single Channel and at Receiver side all channels are separated. (See fig. 1)

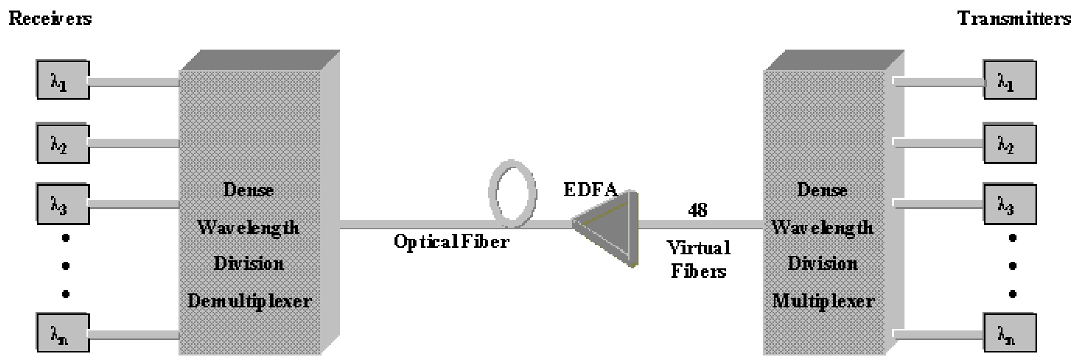

Figure 1: WDM System (5)

In 2013,Sumitpal Singh and Karamjeet kaur proposed three different Dispersion compensation schemes depending upon the positions of DCF:

i. Pre –compensation
ii.Post-compensation
iii. symmetrical-compensation

In pre-compensation scheme, the DCF is placed before the standard single mode fiber (SSMF) to compensate the positive dispersion in SSMF.

In post-compensation, the DCF is placed after the SSMF to compensate the positive dispersion in SSMF.

In symmetrical-compensation, both the schemes (pre-, post-compensation) are used i.e. DCF is placed before as well as after the SSMF to achieve the dispersion(6)

III. Experimental Procedure

For simulation and designing we use optic system 7.0it is an innovative, rapid developing and powerfulsoftware design tool. MATLAB is also used. It helps the users to test and simulate almost all kinds of optical fiber links.The Simulation of three dispersion compensation schemes is shown in below. Table 2 describes the parameter forthe simulation of dispersion compensation systems. The transmitter section consists of modulator driver (NRZ driver), laser source and Mach-Zehnder modulator. A pseudorandom sequence of bits is produce by data source at a rate of 10 Gbit/sMmodulator driver which produces NRZ format pulse with duty cycle of 0.5.Frequecny range is from 193.1 to 193.8. The modulator is of Mach-Zehnder modulators have the Excitation ratio 30db. One loop has been used in loop control system. Each span consists of150 km of transmission fiber (SMF) and20 km DCF in order to fully compensate for the dispersion slope andaccumulated dispersion in the transmission fiber. The total length of fiber channel remains same i.e. 170km. and two EDFA used in front of transmission fiber and DCFfor adjusting the input power level. At the receiver side,PIN diode is used to convert the optical signal into electrical signal.The PIN photodetector have the responsivity1A/W and Dark current 10nA. A low pass Bessel filter is used for filtering the noise.Dispersion is reduced in optical fiber using three dispersion compensation fiber (DCF) techniques. Figures and Tables are shown below

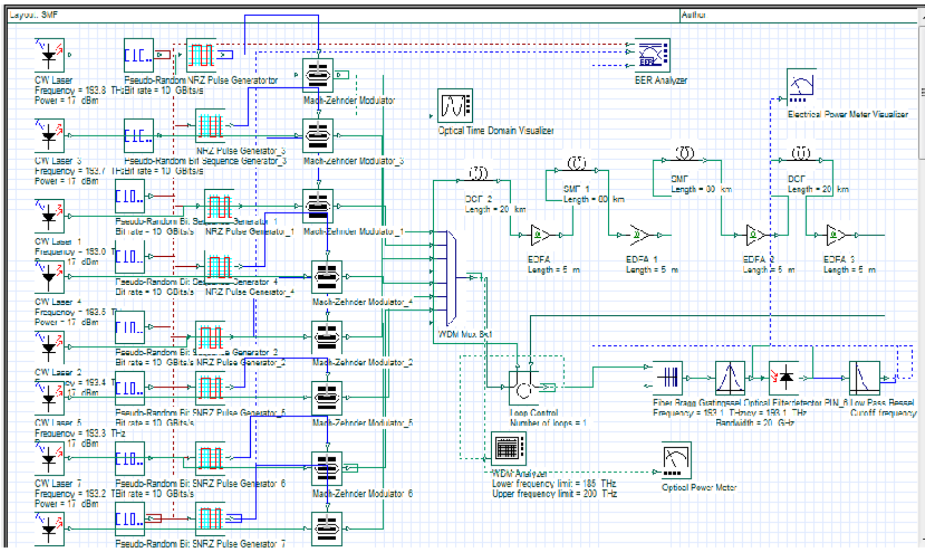

Figure 2:symmetrical compensation

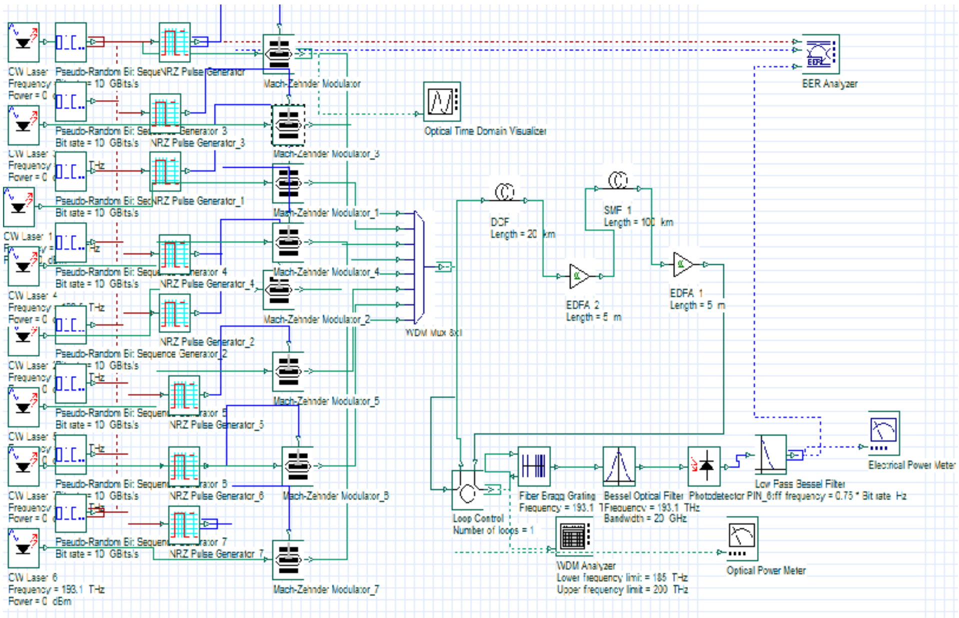

Figure 3:pre compensation

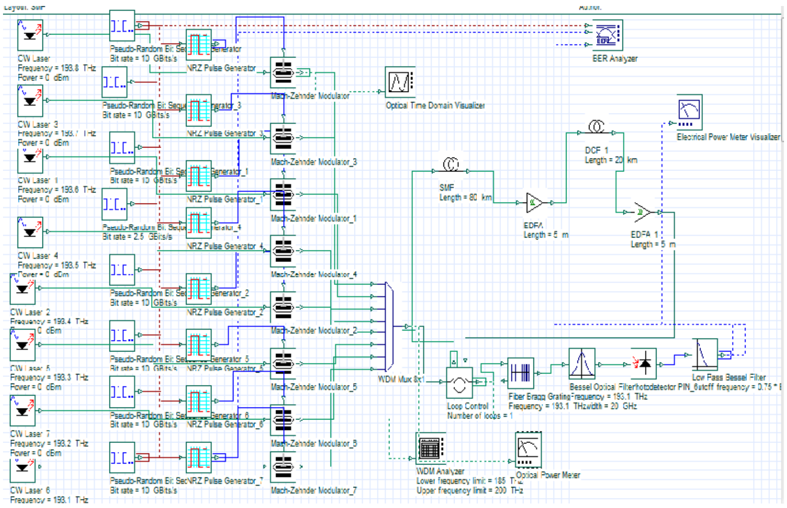

Figure 4:post compensation

Table 1: Fiber parameter

Simulation Parameters	SMF	DCF
Length(Km)	150	20
Attenuation(db/km)	0.2	0.4
Dispersion (ps/nm/km)	16	-80
Differential slope (ps/nm^2/km)	0.08	0.2
Differential group delay(ps/km)	0.5	0.5
PMD coefficient([ps/km)	0.5	0.5

Table 2: Simulation parameter

Parameter	Value
Bit rate	10 Gb/s
Sequence length	128
Samples per bit	64
Central frequency of first channel	193.1
Channel spacing	100 Ghz
Capacity	8channel,10 Gb/s

Table 3: FBG Parameter

Parameters	Value
Frequency(THz)	193.1
Effective index	1.45
Length of Grating	2 mm
Linear Parameter	0.0001um
Apodization function	Uniform
Tanh parameter	0.5

IV. Dispersion Compensation fiber Simulation Results and Discussion

The results obtained by performing various experiments, as described in Section 3.Central frequency of laser is 193.1.Various results are taken at constant fiber length and constant power. Eye diagrams of symmetrical, pre and post compensation schemes are shown below

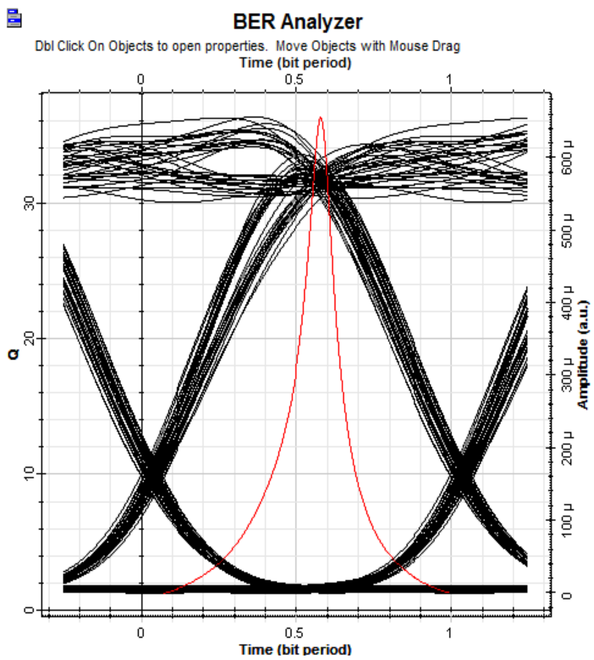

Figure 5: Eye Diagram of Symmetrical Compensation Scheme

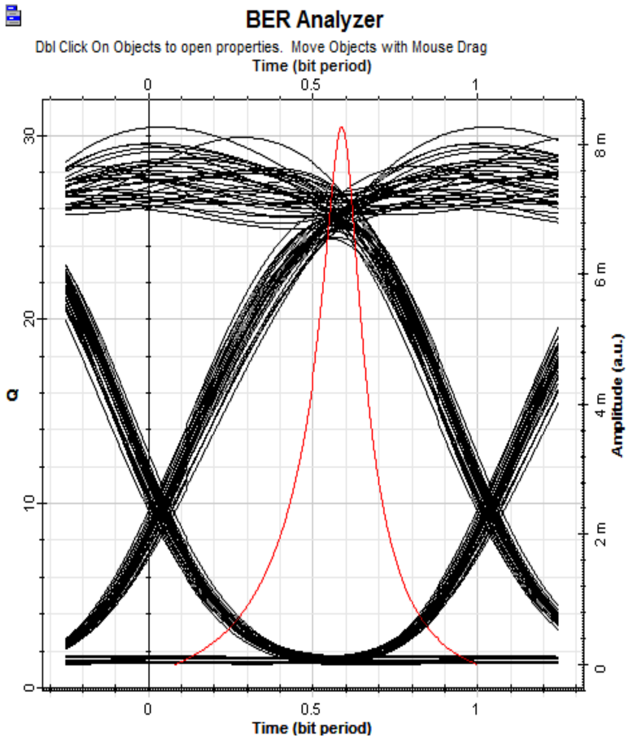

Figure 6: Eye Diagram Of pre Compensation Scheme

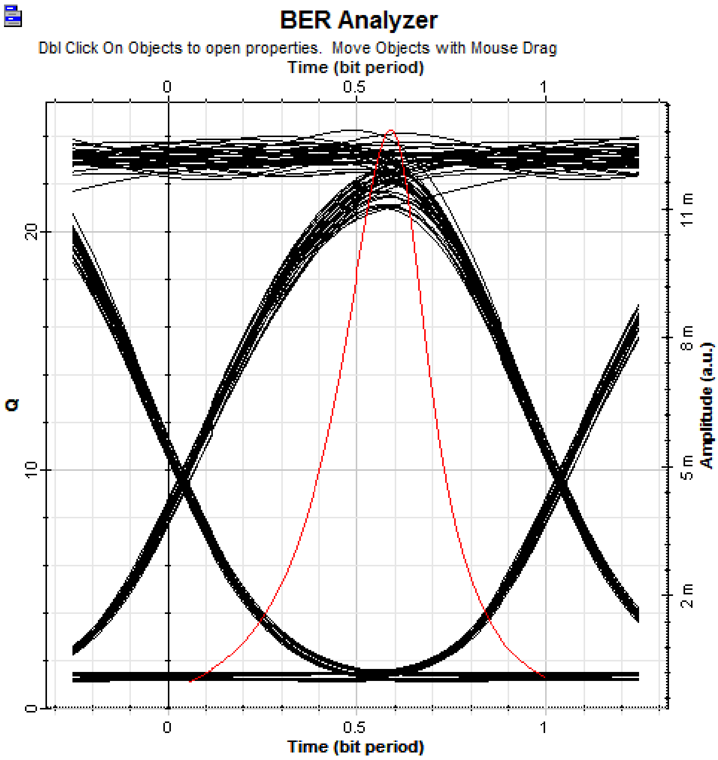

Figure 7: Eye diagram ofpost compensation scheme.

4.1 Results Based on Different length Of SMF at constant Power

Power of CW laser in symmetrical compensation scheme is 17 db, in pre compensation scheme is 0 db and in post compensation scheme is 0 db.

Table 4: Symmetric compensation scheme at constant power

Fiber length	Qfactor	Min BER
40 km	3.24068	0.00585743

60 km	14.652	6.33819e-049
80 km	36.3051	5.56636e-289
100km	9.07408	5.05741e-020
120km	2.34143	0.00891481

Table 5:precompensation scheme at constant power

Fiber length	Q factor	Min BER
20 km	5.34984	4.28533e-008
40 km	8.81284	5.90737e-019
60 km	14.1773	5.89231e-046
80 km	24.3481	2.47826e-131
100 km	30.4378	6.98429e-204
120 km	21.6418	3.00496e-104
150 km	10.0556	3.84285e-024

Table 6: post compensation scheme at constant power

Fiber length	Q factor	Min BER
20 km	5.46546	2.25926e-008
40 km	9.7573	8.21299e-023
60 km	18.3749	8.35781e-076
80 km	24.2468	2.81389e-130
100 km	14.0305	4.74495e-045
120 km	8.04141	4.21463e-016
150 km	3.40282	0.00032862

4.2 Results Based on Constant Fiber Length

Now we take different observation on different input power at constant length. In Symmetrical compensation Length is 80 km and in pre compensation Length is 100 km and in post compensation Length is 80 km.

Table 7:symmetric compensation scheme at constant fiber length

Input power(DB)	Q factor	Min BER
-13	11.7627	2.33875e-032
-11	13.7502	1.97731e-043
-9	15.585	3.61258e-055
-7	17.1495	2.51712e-066
-5	18.6547	4.64114e-078
-3	19.8754	2.69288e-088
0	21.2557	1.19717e-100
3	22.6212	1.09961e-113
5	23.791	1.71607e-125
7	25.4684	1.84261e-143
9	27.2457	7.85522e-164
11	29.9494	1.89487e-197
13	33.8083	6.36965e-251
15	37.705	1.76336e-311
17	36.3051	5.56636e-287
19	28.8288	3.63497e-183
21	17.9646	1.29591e-072
23	9.46378	9.26662e-022
25	4.34905	3.90247e-006

Table 8: pre compensation scheme at constant fiber length

Input power(DB)	Q factor	Min BER
-13	15.1916	1.42208e-052
-11	17.7959	2.74879e-071
-9	20.4966	8.53213e-094
-7	23.1334	8.06614e-119
-5	25.5092	6.01155e-144
-3	28.1162	2.4415e-174
0	30.4378	6.98429e-204
3	28.7638	2.41573e-182
5	25.9832	2.97482e-149
7	22.3959	1.62295e-111
9	19.3889	3.49183e-084
11	16.6889	5.59767e-063
13	14.4787	5.72292e-048
15	12.3246	2.25863e-035

17	10.1814	7.92026e-025
19	8.00143	3.94364e-016
21	5.86223	1.41863e-009
23	4.01216	1.81544e-005
25	2.76048	0.001723

Table 9: post compensation scheme at constant fiber length

Input power (DB)	Q factor	Min BER
-13	11.3805	1.79769e-030
-11	13.7864	1.07695e-043
-9	16.4177	5.13392e-061
-7	18.9226	2.74e-080
-5	21.2181	2.46637e-100
-3	22.8458	6.21476e-116
0	24.2458	2.81389e-130
3	23.4669	3.47932e-122
5	22.0557	3.26059e-108
7	20.0416	9.0893e-090
9	17.462	1.03926e-068
11	14.4413	1.0355e-047
13	11.0856	5.26093e-029
15	7.74646	3.35843e-015
17	4.81839	5.33773e-007
19	2.88289	0.00157191
21	2.39159	0.00639035
23	2.61583	0.00311363
25	2.67965	0.0292538

4.3 Results Comparison Of Transmission Influence Of three Compensation Schemes

Comparison among three compensation schemes and it observed that symmetrical compensation scheme is best as compared to pre and post.

Table 10: Comparison Table among Three different compensation Schemes

Compensation Scheme	Q factor	Min. BER
Symmetrical Compensation	36.3051	5.56636e-287
Pre compensation	30.4378	6.98429e-204
Post Compensation	24.2458	2.81389e-130

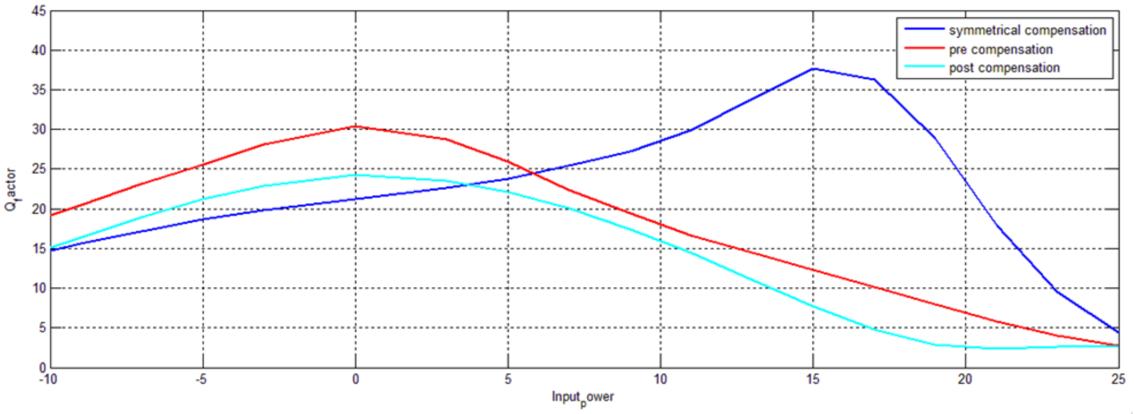

Figure 8: Comparison of Transmission influence of three compensation scheme

Table 11:WDM analyzer for symmetric compensation scheme

Frequency(THz)	Signal power (dbm)	Noise Power(dbm)	OSNR(db)
193.1	-5.2260205	-37.164522	31.938502
193.2	-6.1490528	-37.510563	31.361511
193.3	-7.1510913	-37.510563	30.359472
193.4	-44.694975	-37.901076	-6.7938993
193.5	-40.785991	-38.283144	-2.5028473
193.6	-42.061959	-38.707223	-3.3547352
193.7	-47.184991	-39.108896	-8.0760955
193.8	-12.195541	-39.108896	26.913354

Table 12: WDM analyzer for pre compensation scheme

Frequency(THz)	Signal power (dbm)	Noise Power(dbm)	OSNR(db)
193.1	5.7802255	-29.157584	34.937809
193.2	5.631773	-29.202523	34.834296
193.3	5.4347856	-29.202523	34.637309
193.4	-31.458048	-29.300134	-2.1579135
193.5	-27.990909	-29.376856	1.3859468
193.6	-28.001771	-29.515756	1.5139847
193.7	-32.573254	-29.606949	-2.9663047
193.8	4.7693904	-29.606949	34.37634

Table 13: WDM analyzer for post compensation scheme

Frequency(THz)	Signal power (dbm)	Noise Power(dbm)	OSNR(db)
193.1	8.1539318	-25.055581	33.209513
193.2	7.9731854	-25.15684	33.130025
193.3	7.755662	-25.15684	32.912502
193.4	-33.372157	-25.319989	-8.0521678
193.5	-24.550385	-25.466758	0.91637329
193.6	-23.353647	-25.67757	2.3239226
193.7	-29.821613	-25.842313	-3.9792999
193.8	6.9551826	-25.842313	32.797495

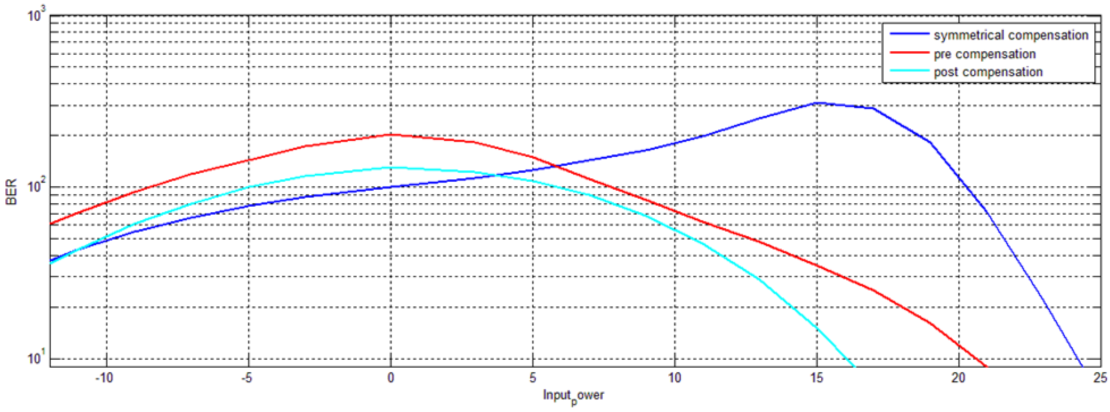

Figure 9: Input power and Min BER Of three compensation Schemes

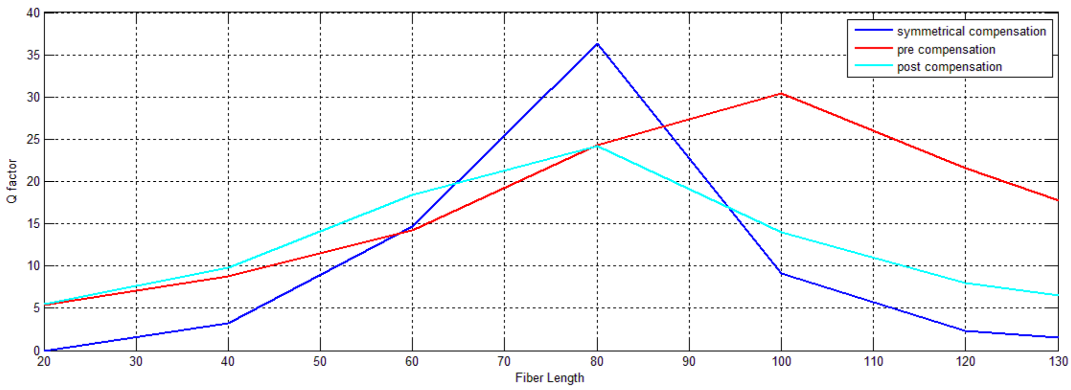

Figure 10: Fiber Length and Q factor of three compensation Schemes

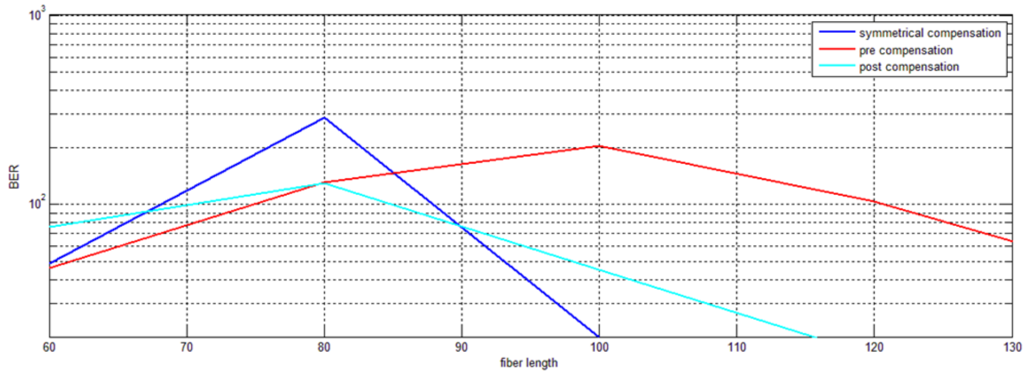

Figure 11: Fiber Length and Min BER of three compensation Schemes

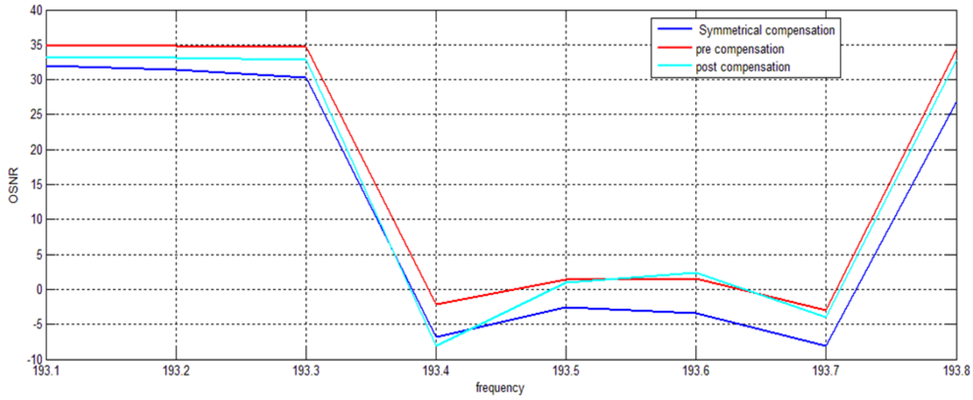

Figure 12: Input frequency and OSNR of three compensation Schemes

V. Conclusion

It is observed that chromatic dispersion and other non linearity effect can be appropriately reduced with the help of dispersion compensation fiber. CW laser have central frequency of 193.1. Q factor and BER is analyzed at different length of fiber. Observation is taken at constant power and on constant fiber length .It has been analyzed that dispersion compensationreduced the dispersion appropriately but among symmetrical compensation scheme reduced the dispersion maximum. From the Above analysis it is clear that Dispersion Compensation Fibers Reduce the dispersion as much possible extend. Symmetrical Compensation Scheme is helpful in reducing the dispersion and quality factor that comes from this technique is 36. We have analyzed the 8 channel WDM system at 10 gbps for different dispersion compensation schemes using DCF and FBG. We observed that the symmetrical-compensation scheme is better than of the pre and post-compensations schemes.

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