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# PERFORMANCE ANALYSIS OF DISPERSION COMPENSATION USING IDEAL FIBER BRAGG GRATING IN A 100 GB/S SINGLE CHANNEL OPTICAL SYSTEM

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## ABSTRACT
In case of long distance communication, high bit rate and large bandwidth are always the primary requirements. The major limiting factor i.e. Attenuation can be reduced by using optical amplifier. But still one more limiting factor is there, which is known as Dispersion, which degrades the quality of optical communication. Hence,in this present investigation, Fiber-optic scattering or Dispersion and its impact on optical transmission are inspected. The most frequently utilized,Fiber Bragg Grating (FBG) method is examined in this article. Three techniques (pre-compensation, post-compensation and blend of these i.e. mix compensation) of dispersion compensation with IDCFBG at input power ranging from 1-10dBm are proposed.A single channel optical system with the help of simulation software i.e. Optisystem is designed by using the above mentioned techniques. The achieved results, for example, Q factor, BER, eye diagram and Eye height are given and profoundly examined. In this investigation, it has been found that Post-Compensation technique execution is appropriate..

**KEYWORDS**: Dispersion; Dispersion Compensation; Fiber Bragg Grating; Optisystem7.0; Scattering; Q-factor; Bit error rate (BER); Chromatic Dispersion (CD); Inter Symbol Interference.

## I. INTRODUCTION
In past few years, with the quick development in web business, individuals desperately require greater bandwidth and best network. So there is a huge interest for more transmission limit and greater data transfer capacity and it is becoming very difficult for the transporters and administrator to fulfill their requirements [1]. Under these circumstances, with its gigantic data transfer capacity and brilliant transmission execution, optical fiber is turning into the greatest conveying media and becoming increasingly essential part in data industry [2]. The ideal outline and use of optical fiber are imperative to the transmission nature of optical fiber transmission. In this way, it is extremely important to research the transmission attributes of optical fiber. As we know, the major aim of any communication system is to enhance the communication distance. Errors and scattering (Dispersion) are the main problems that influence fiber-optical communication and restrict the distance [3].

**Dispersion:** Dispersion is characterized as pulse spreading in an optical fiber. As a pulse of light engenders through a fiber, components, for example, core diameter, numerical aperture, refractive index, wavelength, and laser line width make the pulse expand [4]. Dispersion increases along the fiber length. The general impact of Dispersion on the execution of a fiber optic framework is known as Inter Symbol Interference (ISI). Inter symbol interference happens when the pulse spreading caused by dispersion causes overlapping of pulses. Dispersion is of three types: Modal dispersion, Chromatic Dispersion (CD) and Polarization Mode Dispersion (PMD) [5].

**Modal Dispersion**: Modal dispersion is characterized as pulse spreading caused when delay occurs between lower order modes and higher order modes. Modal scattering is risky in multimode fiber, causing lower bandwidth as shown in fig-1.

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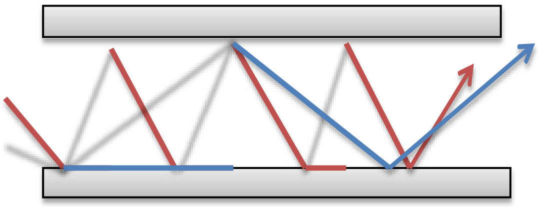

***Figure 1: Modal Dispersion***

**Chromatic Dispersion**: Chromatic Dispersion (CD) is pulse spreading in single mode fiber because of the way that distinctive wavelengths of light do have distinctive velocity. Hence at the receiving end such pulses are received at different intervals of time as shown in fig-2. Chromatic scattering comprises of two sections: material scattering and waveguide scattering [6].


***Figure 2: Chromatic Dispersion***

**Polarization Mode Dispersion**: PMD happens because of birefringence along the length of the fiber in SMF. Whenever a pulse enters inside the fiber, it generally gets divided into two polarization states. One state travels faster than the other causing differential group delay and pulse broadening at the receiver [7].

## II. FIBER BRAGG GRATING

The idea of fiber Bragggrating was first presented in 1980 and has been utilized as a part of a few applications and broadly inquired about. A fiber Bragg grating is a kind of Bragg reflector developed in a short fragment of optical fiber that reflects specific wavelengths of light and transmits all others as shown in fig-3. This is accomplished by making an intermittent variety in the refractive profile of the fiber core, which creates reflection for a particular rwavelength. A fiber Bragg grating can in this manner be utilized as an inline optical channel to hinder certain wavelengths, or as a wavelength-particular reflector. Fiber Bragg Grating can be utilized as a MUX/DEMUX gadget in WDM frameworks for taking out a particular signal (channel) with a specific wavelength from number of signals (channels) [8,9,10,11].

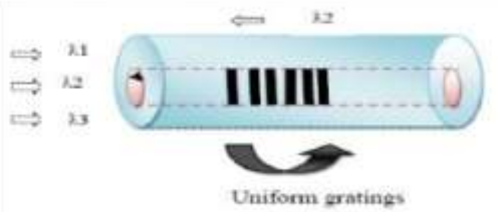


***Figure 3: Fiber Bragg Grating Principle.***

The light which enter into the grating, depend upon the wavelength of light got reflecting by grating.More distance will be travelled by the signal having larger wavelength in grating before getting reflected; on the other hand less distance will be travelled by the signal having small wavelength in the grating before getting reflected. Hence the pulse which is spread by CD in a single mode fiber got reduced by travelling in FBG [12,13]. The

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reflected wavelength ($\lambda_n$) otherwise called the bragg wavelength is given by the relationship shown in equation (1):

$$\lambda(b) = 2n\Lambda \quad (1)$$

*where,*

$n$ *is* effective refractive index of the grating in the fiber core

$\Lambda$ is grating period

Next equation is showing the main wavelength which is also known as Bragg Wavelength, got reflected from the grating is presented by:

$$\lambda(b) = 2n_{eff}\,\Lambda \quad (2)$$

Equation (2) is showing the resultant situation by which signal got reflected.

## III. SIMULATION MODAL

The chromatic dispersion is a noteworthy issue in the single mode fiber when the signals are transmitted over long distance. The primary target of the proposed framework demonstrates was to dissect the execution of fiber Bragg grating as a compensator of dispersion in single channel optic fiber model. In the framework composed, the 100 Gb/s Non Return to Zero (NRZ) signal was propelled onto 120 Km utilizing Single Mode Fiber (SMF) and PRBS (Pseudo Random Bit Sequence) produces the sequence of random bits. The optical Mach-Zehnder Modulator (MZM) was utilized to tweak the optical source and frequency together. Basically, there are three configurations of FBG as follows:

1. Pre compensation: It is defined as when the FBG is kept at the initial point of optical link and before amplifier as shown in fig-4.
2. Post compensation: It is defined as the condition when FBG is kept at the last point of optical link as shown in fig-5.
3. Mix compensation: It is defined as the condition when FBG is used in the center of optical link i.e. between fiber and amplifieras shown in fig-6.

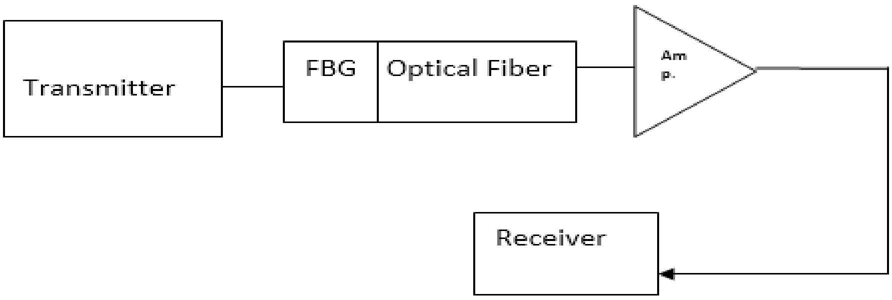


*Figure 4: Block diagram of Pre compensation*

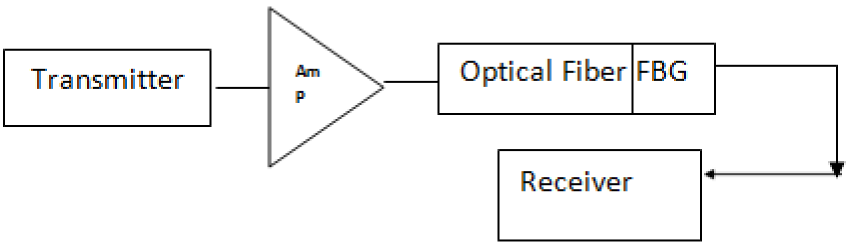


*Figure 5: Block diagram of Post compensation*

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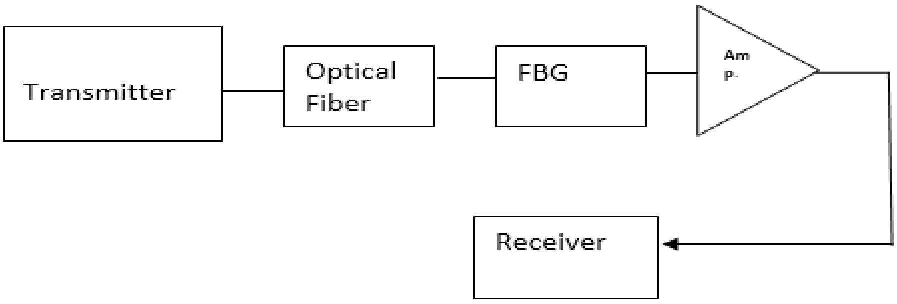


***Figure6: Block diagram of Mix compensation***

The framework outlined was performed utilizing OptiSystem7.0. The fig.7, 8 and 9 show the improvement in dispersion by using single fiber optical connection with the assistance of fiber bragg grating. At the point when the FBG is associated in various plans, for example, pre-compensation, post-compensation and blend of both i.e. mix compensation is connected over the single fiber optical connection, diverse outcomes have been accomplished. Subsequently, at the collector end the outcomes yield was approved by investigated the Q-factor, bit error rate and eye height of various FBG setups. Different reenactments parameters for Simulation and Fiberare used in this examination work as given in Table no.1 and2.

**Table 1: Simulations Parameters**

| Sr. No. | Parameter | Value |
|---|---|---|
| 1 | Bit Rate(Gbps) | 100 |
| 2 | Sample Rate(THz) | 6.4 |
| 3 | Frequency(THz) | 193.1 |
| 4 | Power(dBm) | 1-10 |
| 5 | Extinction Ratio(dB) | 30 |
| 6 | Gain(dB) | 20 |
| 7 | Noise(dB) | 2 |
| 8 | Bandwidth(THz) | 1 |
| 9 | Dispersion FBG(ps/nm) | -2028 |

***Table 2: Fiber Parameters***

| Sr. No. | Parameter | Value |
|---|---|---|
| 1 | Length of Fiber(Km) | 120 |
| 2 | Dispersion(ps/nm/km) | 17 |
| 3 | Attenuation(db/km) | 0.2 |
| 4 | Differential group delay(ps/km) | 3 |
| 5 | Differential slope (ps/$nm2/km$) | 0.008 |

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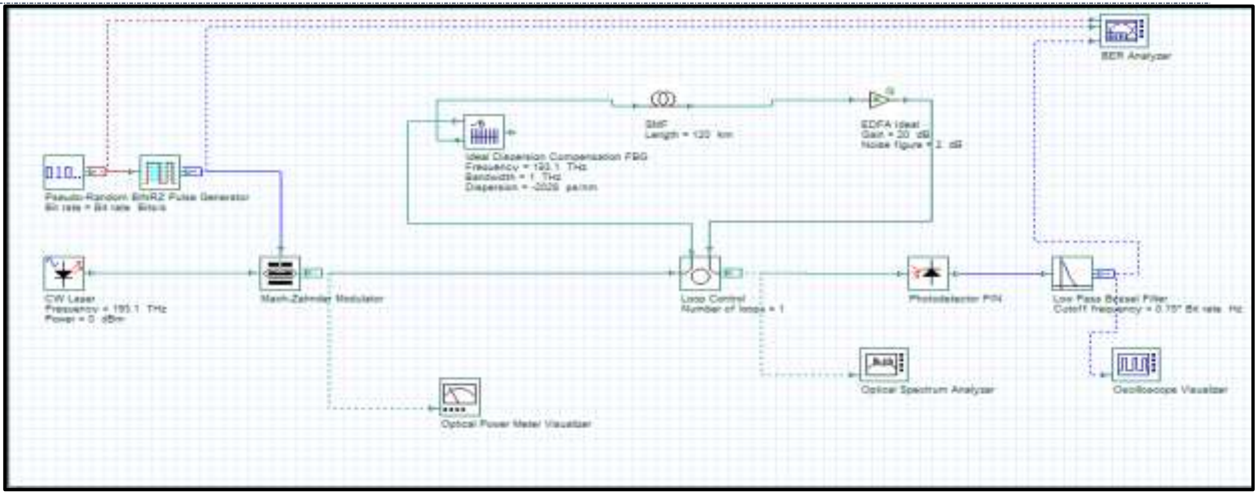


*Figure 7: Pre compensation using IDCFBG simulation model*

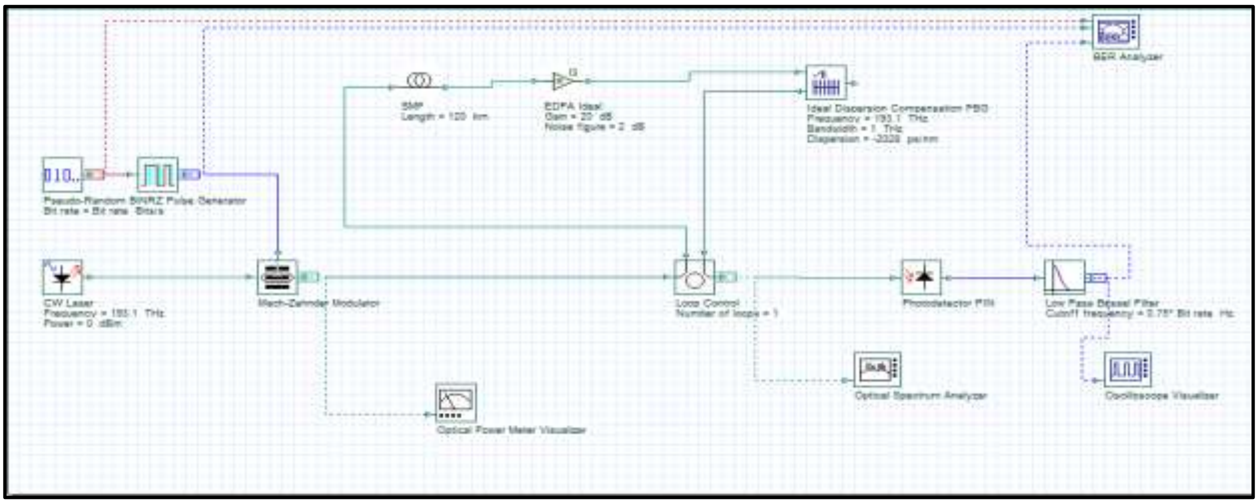


*Figure 8: Post compensation using IDCFBG simulation model*

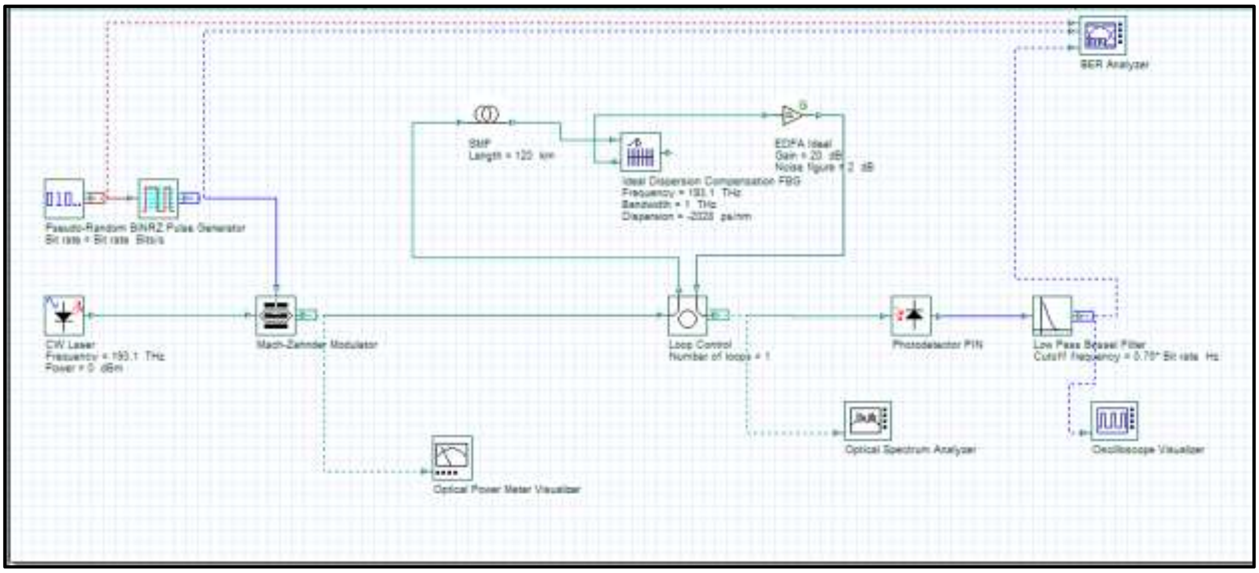


*Figure 9: Dispersion compensation using mix IDCFBG simulation model*

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At first we have utilized a pseudo-random bitgenerator which transmits a succession of 0's and 1's which are provided across the modulator through pulse generator. This string of 0's and 1's is changed over into electrical pulses which are strengthened by Mach-Zehnder modulator which modulates this weak signal with the help of high frequency carrier signal of 193.1 THz. This strengthened signal is then fed to the SMF of length 120km. An EDFA is utilized to compensate errors because of extensive traverse of single mode fiber. At that point the signal is gone through the FBG for compensation by using different schemes shown in figures 7, 8, 9 shown above. The optical data signal is then recovered by PIN photo diode which changed over optical signal to electrical signal. This signal is then gone through a Low Pass Filter with a specific end goal to evacuate all high-frequency components i.e. noise. The signal is at last examined by BER which decides different execution parameters, for example Quality-factor,BER, eye diagram and eye height.

## IV. RESULTS AND DISCUSSIONS

Simulation models of the three configurations are executed by changing its input power from 1-10dBm. After execution, the simulations results are shown in the form of eye diagram shown in fig- 10, 11 and 12 for pre configuration, post configuration and mix configuration. Further the values of Q-Factor, received power (dBm), eye height and BER are described in tabular form. Pre configuration is displayed in Table-3 whereas the outcomes for the post configuration are present in Table-4. The outcomes of mix configuration of IDCFBG at input power 1-10dBm are also shown in Table-5.

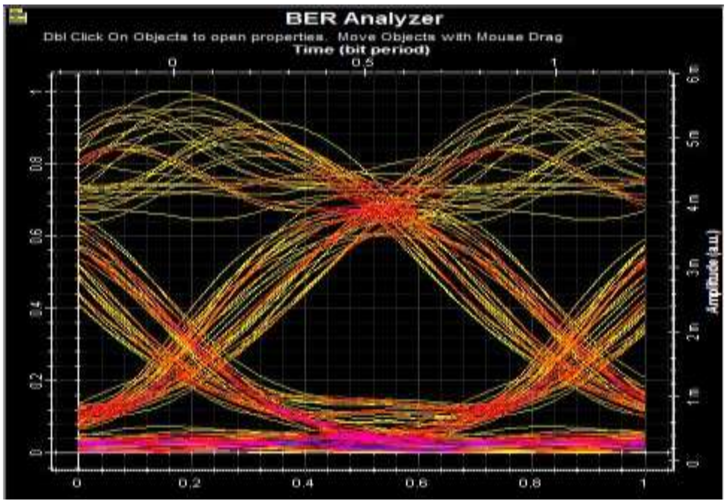


*Figure 10: Simulation Results of pre IDCFBG*

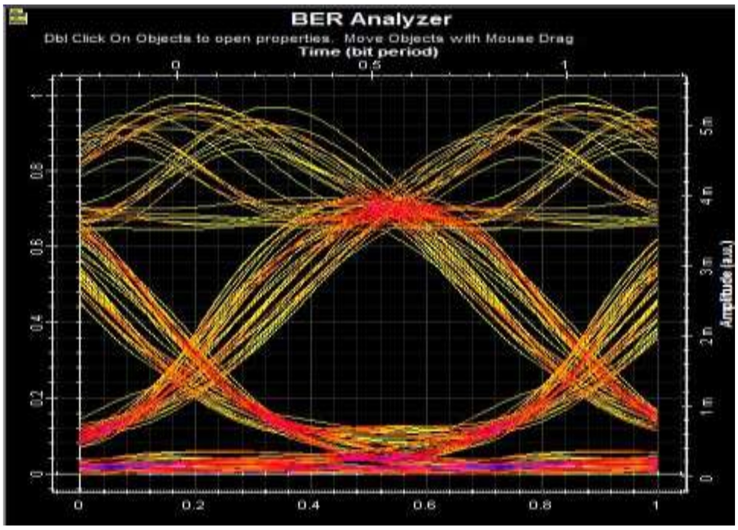


*Figure 11: Simulation Results of post IDCFBG*

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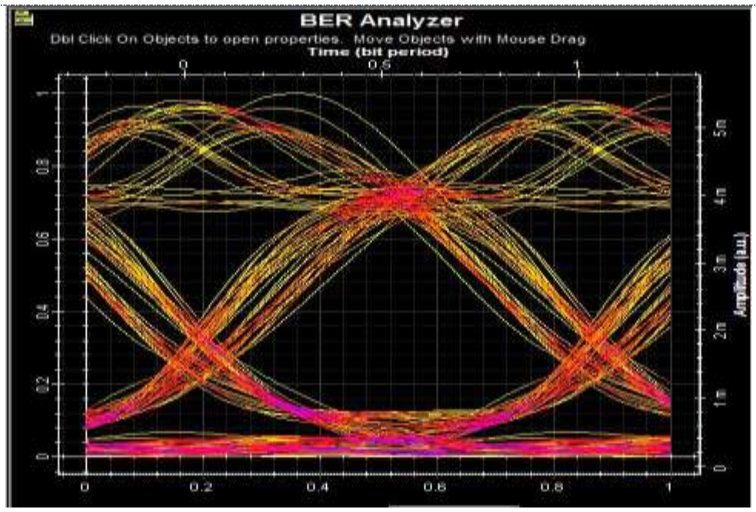


*Figure 12: Simulation Results of mix IDCFBG*

*Table 3: Results for Pre Compensation of IDCFBG at inputs from 1dbm to 10dbm*

| Iterations | Q factor | BER | Eye Height | Power (dbm) |
|---|---|---|---|---|
| 1 | 5.6126 | 9.56E-09 | 0.000207 | -39.25 |
| 2 | 6.0295 | 7.97E-10 | 0.00028 | -37.509 |
| 3 | 6.44271 | 5.74E-11 | 0.000374 | -35.67 |
| 4 | 6.80368 | 5.02E-12 | 0.000492 | -33.788 |
| 5 | 7.13709 | 4.72E-13 | 0.000642 | -31.86 |
| 6 | 7.4555 | 4.46E-14 | 0.000833 | -29.905 |
| 7 | 7.69731 | 6.93E-15 | 0.001071 | -27.93 |
| 8 | 7.84282 | 2.20E-15 | 0.001366 | -25.95 |
| 9 | 7.86216 | 1.88E-15 | 0.001783 | -23.96 |
| 10 | 7.67143 | 8.50E-15 | 0.00214 | -21.96 |

*Table 4: Results for Post Compensation of IDCFBG at inputs from 1dbm to 10dbm*

| Iterations | Q factor | BER | Eye Height | Power (dbm) |
|---|---|---|---|---|
| 1 | 6.2989 | 1.48E-10 | 0.000226 | -39.957 |
| 2 | 6.81376 | 4.73E-12 | 0.000304 | -37.969 |
| 3 | 7.31658 | 1.27E-13 | 0.000404 | -35.978 |
| 4 | 7.87031 | 1.77E-15 | 0.000534 | -33.983 |
| 5 | 8.37922 | 2.66E-17 | 0.0007 | -31.988 |
| 6 | 8.94922 | 1.78E-19 | 0.000915 | -29.98 |
| 7 | 9.43164 | 2.01E-21 | 0.001186 | -27.99 |
| 8 | 9.86961 | 2.18E-23 | 0.00153 | -25.99 |
| 9 | 10.1927 | 1.06E-24 | 0.001962 | -23.99 |
| 10 | 10.2168 | 8.32E-25 | 0.002486 | -21.99 |

***Table 5: Results for Mix Compensation of IDCFBG at inputs from 1dbm to 10dbm***

| Iterations | Q factor | BER | Eye Height | Power (dbm) |
|---|---|---|---|---|
| 1 | 5.642 | 8.03E-09 | 0.00020816 | -39.259 |
| 2 | 6.08952 | 5.47E-10 | 0.000283 | -37.513 |
| 3 | 6.55263 | 2.76E-11 | 0.00038 | -35.682 |
| 4 | 7.03329 | 9.93E-13 | 0.0005058 | -33.793 |
| 5 | 7.50209 | 3.11E-14 | 0.000666 | -31.865 |
| 6 | 8.00555 | 5.92E-16 | 0.000875 | -29.91 |
| 7 | 8.51057 | 8.64E-18 | 0.0011424 | -27.94 |
| 8 | 9.01882 | 9.50E-20 | 0.00148 | -25.959 |
| 9 | 9.51562 | 9.03E-22 | 0.00192371 | -23.97 |
| 10 | 9.8168 | 4.77E-23 | 0.00246 | -21.979 |

The resulting outcomes of the three configurations are analyzed graphically in order to determine the superior configuration of the IDCFBG dispersion compensation technique. All the related graphs for the pre, post and mix configuration of IDCFBG are shown in fig- 13, 14, 15 and 16. Fig-13 is comparing the Q-Factor of the three configurations at various input levels while fig- 14 is showing the variation of BER with change in input power. Similarly, the effect of change in input power on eye height is shown in fig-15. Also, the change in received power with change in input power is displayed in fig-16. After the complete analysis of the graphs, it has been found that at all the parameters, post configuration of the IDCFBG performed well when compared with others.

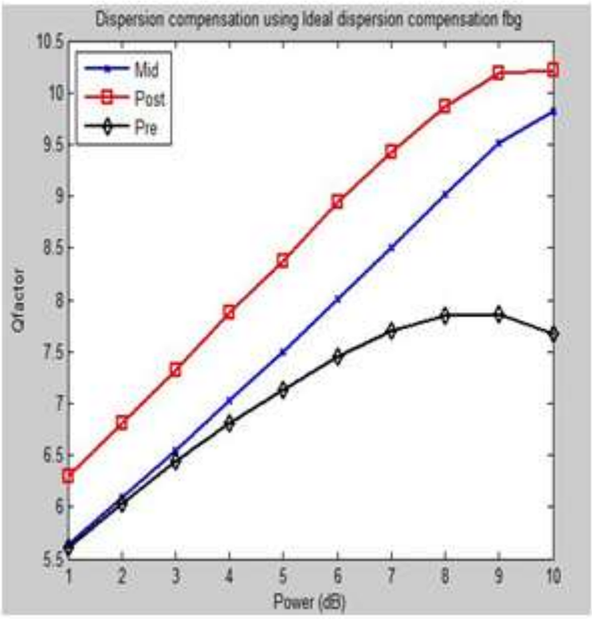


***Figure 13:Input Power Vs Q- Factor***

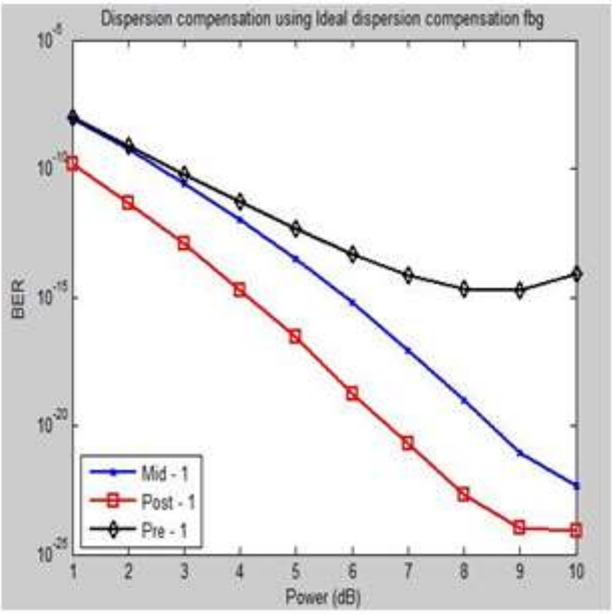


*Figure 14:Input Power Vs BER*

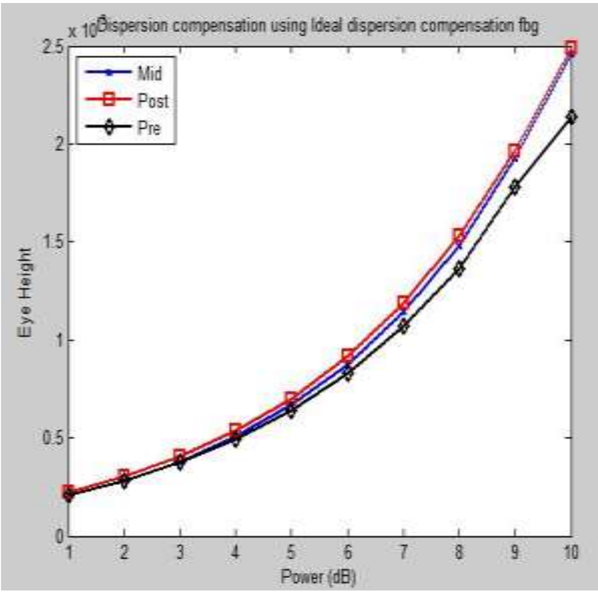


*Figure 15:Input Power Vs Eye Height*

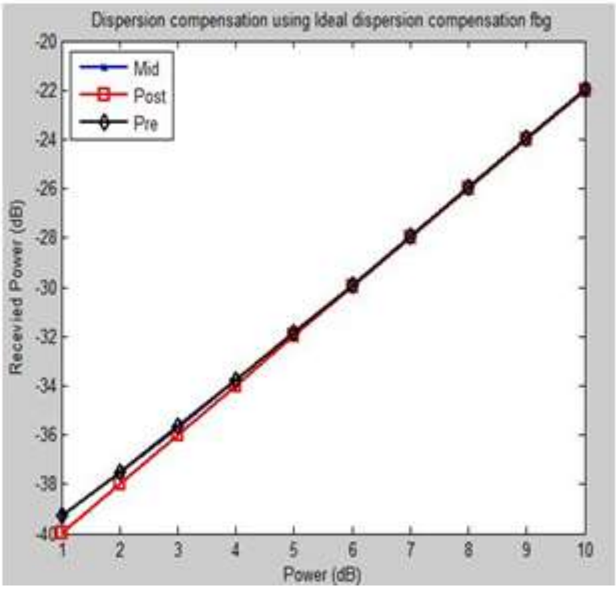


***Figure 16: Input Power Vs Received Power***

## V. CONCLUSION

The dispersion compensation by utilizing IDCFBG in various configurations at the bit rate of 100 Gb/s for 120Km single fiber length are reported in this paper. The outcomes can be seen with the assistance of Q factor, BER and eye diagrams drawn for the different configurations. Moreover we have likewise demonstrated the outcomes with the assistance of comparing all the configurations in terms of Q factor and BER. From the above examination unmistakably FBG reduces the dispersion as much conceivable extends. Post Compensation Scheme is useful in diminishing the dispersion with appropriate quality factor and BER as compare to both of others. We have seen that with the assistance of Fiber Bragg Grating (FBG), the dispersion in optical fiber can be decreased to more noteworthy degree. In any case, we are as yet not ready to totally expel the Dispersion from the optical fiber particularly at higher bit rates, which is a theme of research and a test for the different researchers in the optical fiber field.

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