Performance Evaluation of PWR Technique for a DWDM System using DCF and FBG

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***Abstract* :- In this paper, we employed a Dense Wavelength division multiplexing (DWDM) system in which 96 channel optical network is designed, simulated and then analyzed for long haul distance using Dispersion compensation fiber(DCF) and Fiber Bragg Grating(FBG) technique. Symmetric compensation technique is used for DCF and post compensation technique is used for FBG. The simulation result such as Bit error rate (BER) and Quality factor indicate that DCF is better as compared to FBG.**

Keywords - Pulse Width Reduction (PWR) Dispersion Compensation Fiber (DCF), Fiber Bragg Grating (FBG), Bit Error Rate (BER), Dense Wavelength Division Multiplexing (DWDM)

I. INTRODUCTION

In the modern era, the information and communication networks are one of the emerging technologies in the world [1]. With the increase in the number of internet users, a system with a high bandwidth is one of the most important features that make required. Proper utilization of bandwidth is a system effective. Under the situation, with its huge bandwidth and excellent transmission performance, optical fiber is becoming the most favorable delivering media and laying more and more important role in information industry [2],[3]. The main aim of optic fiber networks is to make them more effective which results in minimum loss in signal and good quality transmission with minimum error [4], [5].

The DWDM system has been used in an optical fiber network to meet the demands of huge bandwidth and high Capacity networks. DWDM system is used to transmit various signals concurrently each having different wavelengths. Whenever a signal propagates inside an optical fiber, then the intensity of the light signal reduce due to various losses that occur during the communication. When a light signal is transmitted over a long span of optical fiber, the power of signal scatter with respect to time which results in the widening of the shape of the pulses with time Due to this broadening of pulses, the mixing of signals takes place, causing the Inter symbol Interference (ISI) and as a result of this receiver in not able to recover the signals. This phenomenon is said to be dispersion. Dispersion arises due to the fact that the group velocity (and group delay) of the optical signal propagating in a fiber depends on the refractive index of the doped silica, which is a nonlinear function of wavelength [6]. It is easy to see that the dispersion become the major factor that restricts long distance fiber-optical transfers [7].In order to mitigate the effect of dispersion, two techniques i.e. DCF and FBG are used.

II. BASICS OF DCF & FBG

Dispersion compensation fiber (DCF) is a kind of optical fiber which has dispersion characteristics opposite to that of transmission link fibers. The optical fibers have positive dispersion in a C- band operated at a wavelength of 1550 nm and has about 18 ps/(nm.km) dispersion. Whenever the signal transmit through a long distance, the accumulated positive dispersion become big which reduces the signal to noise ratio and increase in bit error rate[11-15]. In order to compensate this DCF is designed which have a negative dispersion in the range of -70 to -90 ps/(nm.km). Performance degradation in optical system is because of group velocity dispersion, Kerr nonlinearity, and accumulation of amplified spontaneous emission noise due to periodic amplification [10]. A DCF should have low insertion loss, low polarization mode dispersion and low optical nonlinearity and should have large Group Velocity Dispersion Coefficient to minimize the size of a DCF. Smaller size of the DCF is preferable [4], [8]. By placing one DCF with negative dispersion after a SMF with positive dispersion, the net dispersion should be zero.

$$\mathbf{D_{SMF} \times L_{SMF} = - D_{DCF} \times L_{DCF}} \qquad \textbf{(1)}$$

Where D is the dispersion and L is length of each fiber respectively.

FBG is a dispersion compensator which is used to compensate the Group Velocity Dispersion that occurs at the multiple variations of the wavelength. The chirped FBG(CFBG) which works on the principle of diffraction gratings enable the grating reflect the various wavelengths at different points along its grating length which sets the delays for all different wavelengths. The range of reflected wavelengths is provided by [9]

$$\boldsymbol{\Delta\lambda_{CHIRP} = 2n_{eff} (\Lambda_L - \Lambda_S)} \qquad \textbf{(2)}$$

Where λ_L is the longest wavelength, λ_S is the shortest wavelength, $\Delta\lambda_{CHIRP}$ is the difference between λ_L and λ_S, Λ_L is the longest grating period, and Λ_S is the shortest grating period

III. SYSTEM STRUCTURE DESIGN

DWDM system consist of 96 channels, each having 10 Gbps bit rate making the total bit rate of 960 Gbps. At the transmitter side each individual channel consists of Pseudo Random Bit Sequence followed by the NRZ pulse modulator. CW laser is used whose input power is varied. Different channels have different frequencies which may vary from 195.1 to 197.5 THz followed by the Mach Zhender Modulator (MZM). The output of MZM is applied to 96 × 1 multiplexer which is used to multiplex different wavelengths.

Fig 1 represents the system setup for dispersion compensation using DCF.

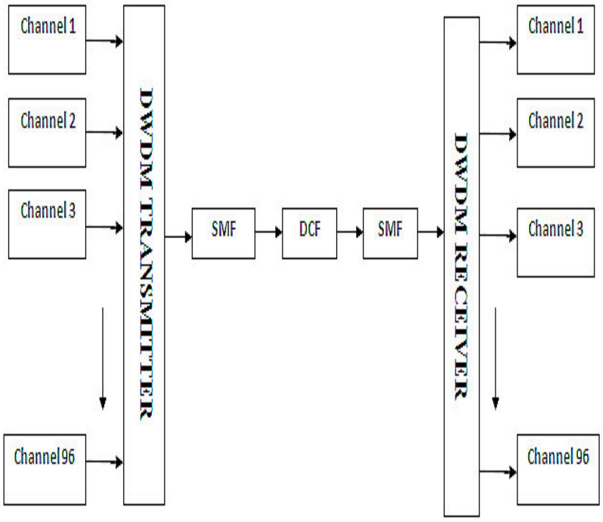


Fig 1. System setup for Dispersion Compensation using DCF

50 km single mode fiber (SMF) is used to make transmission link in which DCF or FBG is used in order to mitigate the effect of dispersion EDFAs (Erbium Doped Fiber Amplifier) of gain 20 dB are used after span of 25 km SMF and 10 km DCF. Fig 2 represents the system setup for dispersion compensation using FBG.

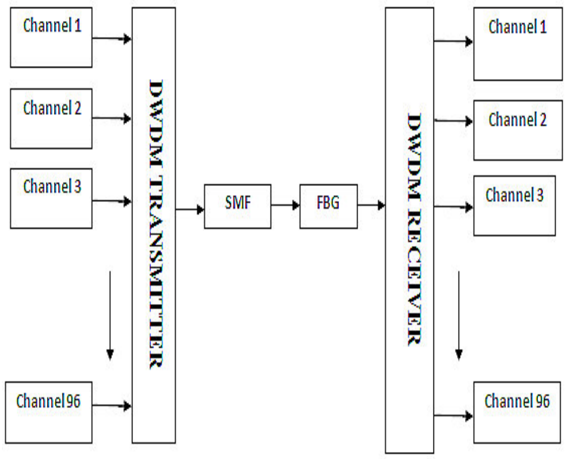


Fig 2. System setup for Dispersion Compensation using FBG

At the receiver side 1 × 96 demultiplexer is used followed by the PIN photodiode whose responsivity is 1 A/W. Low pass filter at the particular frequency is used and the BER analyzer is used to get the results of Quality factor and BER.

IV. SIMULATION RESULTS

In DWDM system, Quality Factor is one of the most important parameter that is used to measure the performance of the system. The graph is plotted between the Quality Factor and the distance by increasing the distance maintaining the input power of the laser constant. The graph in Fig 3 represents the comparison of Quality factor for DCF and FBG.

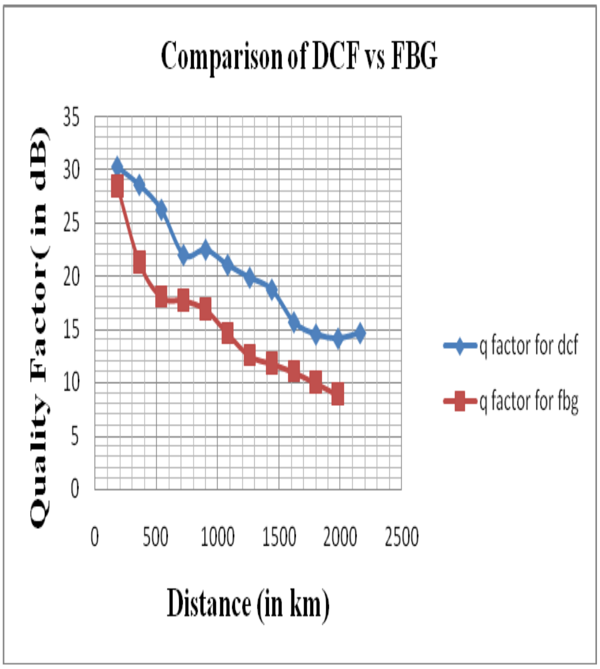


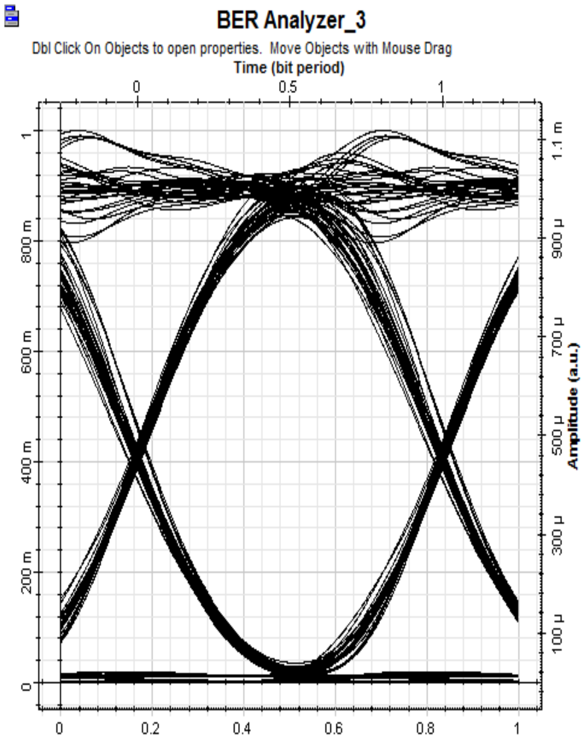
Fig 3. Quality Factor vs Distance using DCF and FBG technique

The change in the quality factor by varying the distance is shown in fig 3. Between the DCF and FBG technique , DCF gives the most effective result. The FBG signal travels upto distance of 2180 km whereas the DCF signal travels upto the distance of 3000 km with an acceptable bit error rate and quality factor.

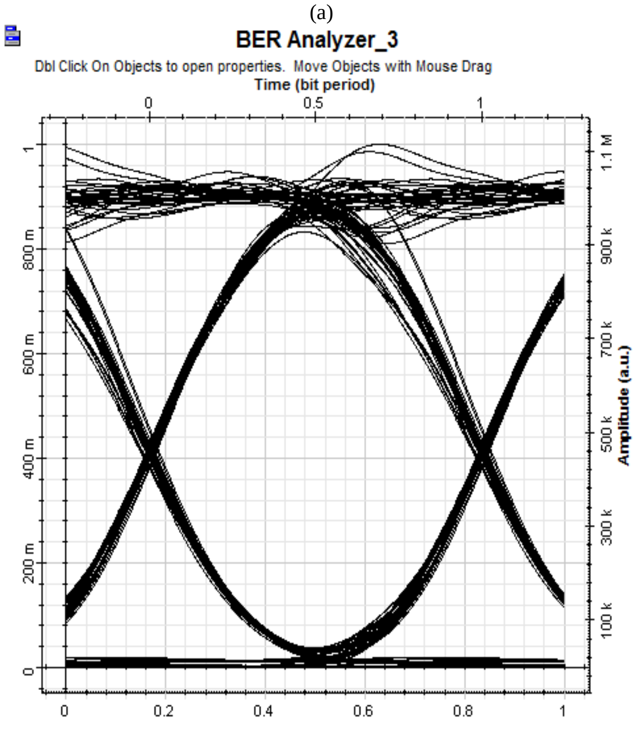
Table I shows the result for BER using different compensation techniques at the 0 dBm input power and from the table it is clear that after the transmission of signal at long distance, BER for DCF is far far better than the FBG.

Table I. BER for DCF and FBG (at 0 dBm input power)

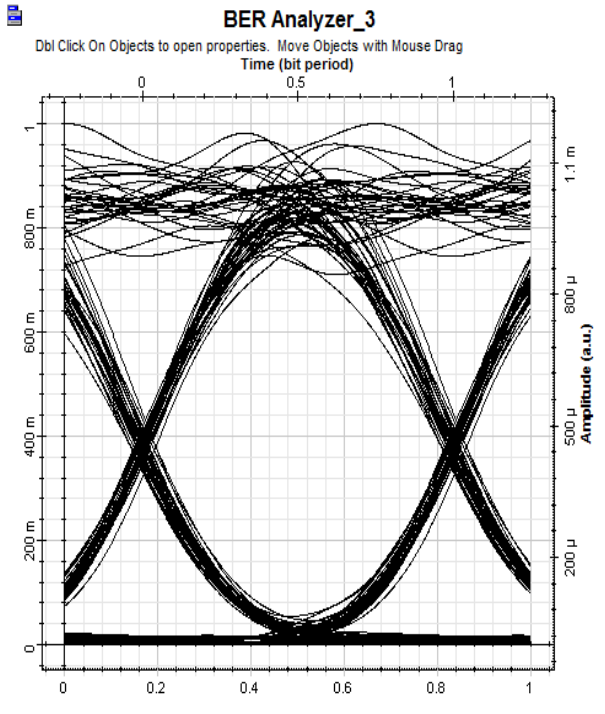
Distance (in km)	BER of DCF	BER OF FBG
1800	3.133e-48	1.079e-23
1980	6.987e-46	4.064e-19



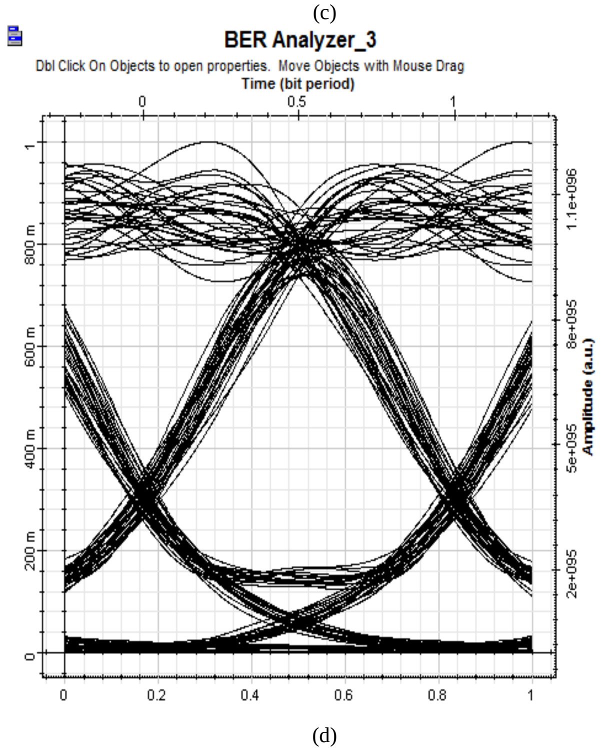
(a)



(b)



(c)



(d)

Fig 4. Eye diagram a) using DCF at min distance b) using FBG at min. distance c) using DCF at max. distance d) using FBG at max. distance

Eye diagram using the different compensation techniques at minimum and maximum distance is as shown in fig 4. Eye diagram is very useful for determining the Inter Symbol Interference (ISI). The width of eye determines the ISI. More the width of eye, lesser is the ISI. Fig 4(a) and 4(b) represents the eye diagrams for DCF and FBG at minimum distance of 180 km and both the diagrams represents that the noise has not severe effect on the optical transmission signal. Fig 4(c) and 4(d) represents the eye diagrams at the maximum distance of 2180 km and from the figure it is clear that DCF technique has less noise effect as compared to FBG. The ISI is less in case of DCF as compared to FBG because the width of eye in case of DCF is more as compared to FBG.

V. CONCLUSION

In this paper we have presented the two different compensation techniques i.e. Dispersion compensation fiber and Fiber Bragg grating in order to mitigate the effect of dispersion. DCF is very much better as compared to FBG for 96 channels DWDM system using NRZ modulation format. DCF technique provide an acceptable bit error rate and quality factor at a distance of 3000 km whereas FBG provide an acceptable bit error rate and quality factor at a distance of 2180 km. As DCF technique provide a good dispersion compensation unit but it is costly for a standard link in the system. So in order to minimize the cost of the system hybrid technique i.e. DCF along with FBG is used to achieve the remarkable dispersion compensation.

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