International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-6, April 2020

Simulative Analysis of Various Mitigation Schemes in WDM Optical Network

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Abstract: ***The growth of optical systems is stimulated for high channel capacity and high bandwidth to meet the explosive development in data communication. Most of the voice and data traffic is transmitted through optical fiber link in these days. In order to share the large bandwidth of optical fiber by multiple channels of different wavelength with higher data rate WDM networks are used. The performance WDM networks are highly effected by the nonlinear dispersion which needs to be managed. In this paper the performance of WDM optical network is analyzed by using Dispersion compensation fiber, fiber bragg grating, and polarization controller. It has been concluded from the results that the use of polarization controller provides the high quality output as compare to Dispersion compensation fiber, fiber bragg grating for each channel.***

Keywords: DCF, Dispersion, FBG, Nonlinearities, PC, Quality Factor

I. INTRODUCTION

Change in refractive index in due to intensity of the medium inelastic-scattering generates the nonlinearity's in an optical fiber. This nonlinearity's can be classified in two categories i.e. based of Kerr effect and scattering effect. In multichannel systems such as WDM this nonlinear effects increase the gain to certain channel and reducing power of other channels. With this process phase of signal go changes and cause spectral widening hence leads to increase in dispersion [1-2] In Literature many methods are available to reduce the impact of these nonlinearities. In this paper the output of various channel of WDM has been analyzed by using polarization controller, dispersion compensation fiber, and fiber Bragg's Grating. As the dispersion is inescapable in optical fibers, so dispersion compensating fibers, are incorporated into optical systems due to opposite in sign of the overall dispersion of these fibers and it is considerably bigger in magnitude than that of standard optical fiber. DCF may be used for cancelling or compensating the dispersion of a standard optical fiber, just like in nonzero dispersion-shifted fiber. The use of dispersion compensation fiber is most prevalent method which is proposed and demonstrated by Lin et al [3-4].

Revised Manuscript Received on April 30, 2020.
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The value of dispersion and attenuation optical link is given by following relations

$$D_T = D_{SMF} L_{SMF} + D_{DCF} L_{DCF} \quad (1)$$

$$\alpha_T = \alpha_{SMF} L_{SMF} + \alpha_{DCF} L_{DCF} \quad (2)$$

High value of negative dispersion in DCF and low value of attenuation are required for a system to be an efficient system. The term figure of merit for DCF can be defined as follows

$$FOM = -\frac{D_{DCF}}{\alpha_{DCF}} \quad (3)$$

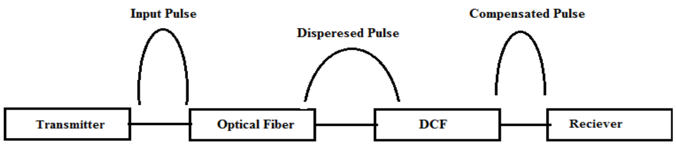

Fig 1. Block Diagram of DCF Compensated Optical Link

Finally equation 1, 2, 3 can be combined to determine total losses as given in equation 4.

$$\alpha_T = \left(\alpha_{SMF} + \frac{D_{SMF}}{FOM} \right) L_{SMF} \quad (4)$$

So FOM is used for estimation of attenuation in DCF.
Fiber Bragg Grating in which refractive index is periodically modulated in the core of a single mode optical fiber is used to reduce influence of chromatic dispersion. FBG is a furthermost effectual technologies used in study to minimize chromatic dispersion. [5-6]The conditions of Energy conservation and momentum conservation are fulfilled by FBG.

For the 1st order Bragg condition is as follows:

$$\lambda_B = 2 n_{eff} \Lambda \quad (5)$$

Here λ is Bragg grating wavelength, B is the free space, Wavelength, is refractive index of optical fiber and Λ is the grating separation of the FBG [7-10].
Polarization Mode Dispersion very severe impairments which causes pulse broadening and limits the performance of long distance fast speed optical systems. PMD is having low effect in low data rate transmission systems. But PMD need control in long distance systems with higher data rate. These light waves travelling through optical fiber are consisting of i.e., electric and magnetic fields which are perpendicular to direction in which light is traveling and perpendicular to each other.

Refractive index of the fiber decides the speed of light in fiber core i.e. the more the value of refractive index of the fiber, less speed of light and vice versa. The Polarization Mode Dispersion depends on the variation of refractive index of optical fiber. The birefringence and DGD are causes PMD. The change in temperature and stresses in optical fiber may change r the value of refractive index .Due to rise in temperature the refractive index fluctuates randomly over the wavelengths which results in varying wavelength speeds.So the refractive index of the horizontal and vertical axis will be different .This Difference in refractive index generates two orthogonal states of polarization. Hence it causes the birefringence in which the light gets split up into fast axis and slow axis. When a ray of light enters a fiber variation in theses birefringence cause the variation in PMD.The equation for birefringence as, follows

$$\Delta\beta = \beta_s - \beta_f \qquad (6)$$

Where $\beta_s = \frac{2\pi n_s}{\lambda}$ Phase shift by the slow axis and $\beta_f = \frac{2\pi n_s}{\lambda}$ Phase shift by the fast axis, If Δβ is zero it means no birefringence hence no pulse broadening.

Differential Group Delay is generated in between two polarization states due to PMD as shown in figure 2.so DGD is just a difference in propagation times in between two polarization states. First order Polarization is the differential time delay in between propagation modes. Second order PMD and higher order PMD occur due to dependence of DGD on frequency. This higher order PMD limits the Data rate.

Mathematical expression for DGD is given as follows

$$\Delta\tau_{PMD} = D_{PMD} * \sqrt{L} \qquad (7)$$

Here L is the length of fiber channel , DPMD is value of PMD and .Units if DGD is ps.

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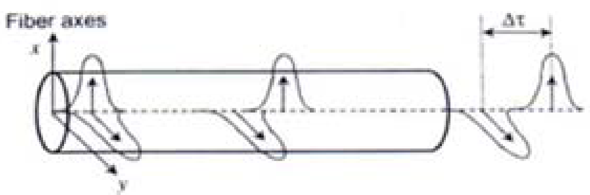

Fig 1.2: Differential Group Delay [12]

Polarization of optical signal light arises when two orthogonal electrical vector field components having varying amplitude travels along the fiber. Degree of Polarization, Polarization Extinction Ratio, Polarization Dependent Loss and Polarization Mode Dispersion are properties used to the determinate the polarization.. The research is going on polarization continually for either reduce or exploit the phenomenon. The devices which are used to control are called the impact of polarization are called as polarization controller, [11-12].

II. SIMULATION MODEL

In the history of optical fiber communication development of wavelength division multiplexing (WDM) is great achievement .WDM is based on the principle that light signals having different wavelengths can be combined together and transmitted through a single optical fiber and the wavelengths can be separated at receiver side .To evaluate the performance of wavelength division multiplexing system with three different mitigation methods the model used is as shown in figure 2.1.In transmitter side four channels each of which having laser used to generate light waves with frequency value 193.1 THz, 193.2THz, 193.3 THz and 193.4 respectively. In the transmission part, NRZ pulse generators are for the purpose of controlling the bandwidth. Pseudorandom bit sequence generator is used to scramble data signal in terms of bit rates. and Mach-Zehnder modulator is also the part of transmitter with 5 dBm and 30 dB of extinction ratio. To manage dispersion, we use Fiber Bragg Grating, DCF, PC has been used.The optical signal from the fiber is transformed into electrical signal by using PIN photodiode eye diagram analyzer is used for obtaining the Q value.

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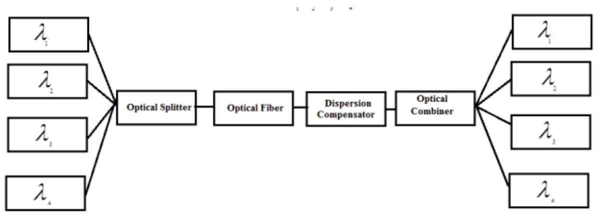

Figure 2.1 Proposed simulation model

III. RESULTS AND DISCUSSIONS

The simulative results obtained are as shown in figure 3.1 to 3.4.In this work performance of proposed model habs een compared with different dispersion compensation methods the quality factor is examined for different channel of WDM network.

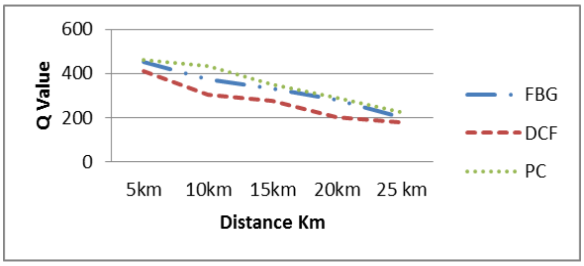

Fig. 3.1 Q value versus Distance Km for Channel 1

The investigation has been done up to the distance of 25Km to with step size of 5Km for three methods of dispersion compensation i.e. DCF FBG and PC. For channel one Q value obtained for FBG is 17, 32, 17.26, 17.17, 17.12, 17.03, for DCF 17.26.17.2, 17.12, 17.03 and for PC it is 17. 32, 17.24, 17.17, 17.09, 16.98. For channel two Q value FBG is 17, 24, 17.18, 17.1, 17.01, 16.9, for DCF 17.18, 17.1, 17.01, 16.9, and 16.77 and for PC it is 17.24, 17.14, 17.06, 16.95, and 16.83. Similarly for channel three 17.32, 17.26, 17.22, 17.12, 17.04 are the obtained Q values for FBG, 17.26,17.2, 17.12, 17.04, 16.94 for DCF , 17.32 ,17.24, 17.17, 17.08, 16.99 is for PC. Finally for FBG 17.35, 17.25, 17.18, 17.12, 17.01, For DCF 17.2617.1917.12, 17.03, 16.93 and 17.31, 17.23, 17.16, 17.08, 16.98 for PC are the attained Q Values

Retrieval Number: F4548049620/2020©BEIESP
DOI: 10.35940/ijitee.F4548.049620
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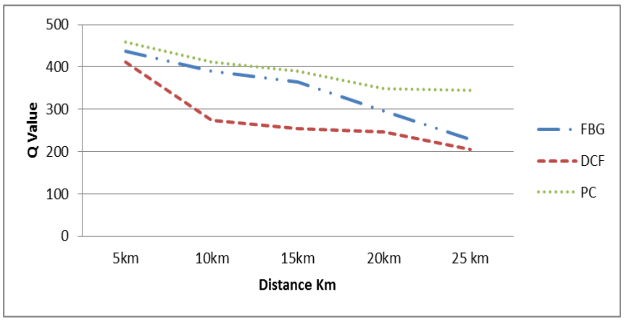

Fig 3.2 Q value versus Distance Km for Channel 2

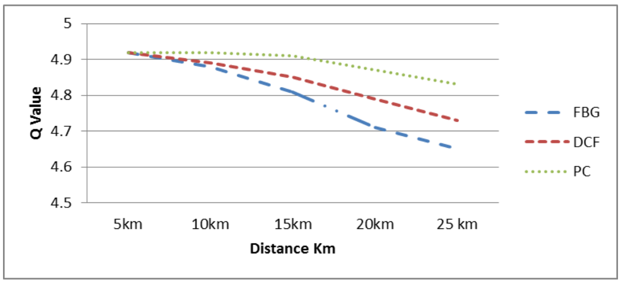

Fig. 3.3 Q value versus Distance Km For Channel 3

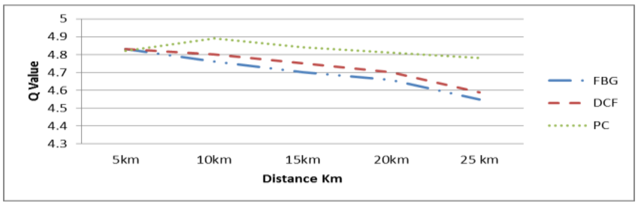

Fig. 3.4 Q value versus Distance Km For Channel 4

IV. CONCLUSIONS

In optical communication the light signal transmitted to destination using optical fiber as a channel. High capacity, high security, larger BW and low BER, are the major advantages of optical communication systems. Wavelength division multiplexing is used to enhance the capacity optical system. But the WDM suffers from the nonlinear effect and hence the overall performance is degraded. To overcome impact of nonlinear effects in WDM optical transmission systems the three different namely DCF, FBG, PC method has been tested in this paper. For the purpose of the comparison of the performance of this method Q value is obtained. PC is found to be very high efficient as compared other methods by achieving high value of quality factor in terms of frequency spacing. Because replication is required for scientific progress, papers submitted for publication must provide sufficient information to allow readers to perform similar experiments or calculations and use the reported results. Although not everything need be disclosed, a paper must contain new, useable, and fully described information. For example, a specimen's chemical composition need not be reported if the main purpose of a paper is to introduce a new measurement technique. Authors should expect to be challenged by reviewers if the results are not supported by adequate data and critical details.

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