

Performance Analysis of Dispersion Compensation in Long Haul Optical Fiber using DCF

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ABSTRACT

In this paper, We investigate post, pre and symmetrical/mix dispersion compensation methods for 40 Gb/s non-return to zero (NRZ) link using standard and dispersion compensated fiber through FBG compensator to optimize high data rate optical transmission. The influence of dispersion of FBG compensator and increases in the power of CW laser has been studied to evaluate the performance of optical communication systems. The simulation model of the WDM based on the Optisystem 12.0 is presented according to the above principle. The simulation results are validated by analyzing the Q-factor and bit error rate (BER) in the numerical simulator. It is found that post compensation performance is good and the input fiber power is taken as 5 to 10dB, the corresponding BER performance is better.

Keywords - Dispersion compensation, optical communication DCF, Q-factor, simulation.

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I. INTRODUCTION

When optical signals are transmitted over optical links, different wavelength components of the optical signals will generally experience different propagation times due to the fact that the transport medium has different effective refractive indices for different wavelengths. In recent years, with the rapid growth internet business required, people fastly required more capacity and network systems. So the demand for transmission capacity and bandwidth are becoming more and more challenging to the carriers and service providers. Under the condition, with its large bandwidth and excellent transmission performance, optical fiber is becoming the most favourable delivering media and laying more and more important role in information system [2,3].

Therefore, it is compulsory to inspect the transmission characteristics of the optical fiber, and the main goal of communication system is to increase the transmission distance. Loss and dispersion are the major factor that affect fiber-optical communication being the high-capacity develops. The EDFA is the gigantic change happened in the fiber-optical communication system; the loss is no longer the major factor to limit the fiber optical transmission. Since EDFA works in 1550 nm wave band, the average Single Mode Fiber (SMF) dispersion value in that wave band is very big, about 15-20ps / (nm.km-1). It is easy to see that the dispersion become the major factor that limits long distance fiber optical transfers [4]. In this study, we propose three DCF compensation scheme, post-compensation, pre-compensation and symmetrical/mix compensation scheme. Simulation studies show that post compensation scheme is the best. It can greatly decrease the impacts of the fiber nonlinearity and increase the transmission distance greatly.

The rest of paper is organized as followed. In Section II, the cause of fiber dispersion and its effects on optical transmission is introduced. In Section III, present fiber dispersion compensation technology. In Section IV, present the research of DCF dispersion compensation scheme. Section V present transmission system simulation with optisystem 12.0, analyses and compare each kind of compensation scheme and Section VI concludes the paper.

II. FIBER OPTIC DISPERSION ON OPTICAL TRANSMISSION

Loss and dispersion are the main factor that affect fiber-optical communication being the high-capacity matures. The EDFA is the gigantic change happened in the fiber-optical communication system, the loss is no longer the main factor to restrict the fiber-optical transmission. Since EDFA works in 1550 nm wave band, the average single mode fiber (SMF) dispersion value in that wave band is very giant, about 15-20ps / (nm. km-1). It

is easy to see that the dispersion become the main factors that limit long distance fiber-optical transfers. Dispersion is defined as because of the different frequency or mode of light pulse in fiber transfers at different rates, so that these frequency components or models receive the fiber terminals at different time. It can cause insufferable amounts of distortions that eventually lead to errors. In SMF performance is primarily bounded by chromatic dispersion which occurs because the refractive index (RI) of the glass varies slightly depending on the wavelength of the light, and light from real optical transmitters necessarily has non-zero (NZ) spectral width. Polarization mode dispersion (PMD) another source of limitation occurs because although the SMF can withstand only one transverse mode, it can convey this mode with two different polarizations, and slight distortions in a fiber can change the propagation velocities for the two polarizations. This phenomenon is called birefringence. Mode birefringence B_m is defined as the follow

$$B_m = \beta_x - \beta_y / k_0 = n_x - n_y \quad (1)$$

Where n_x , n_y are the effective refractive of the two orthogonal polarizations. For a given B_m , its fast axis and slow axis components will be formed the phase difference after the light waves transmission L Km.

$$\varphi = k_0 B_m L \quad 2\pi/\lambda \quad (N_x - N_y) = (\beta_x - \beta_y)L \quad (2)$$

If the B_m is a constant, through the light waves in transmission process the phase difference between its fast axis and slow axis will periodicity recurrence. The length that it leads to a phase difference of 2π or power periodic interchange is called polarization beat length.

$$LB = 2\pi/\beta_x - \beta_y = \lambda/\beta_m \quad (3)$$

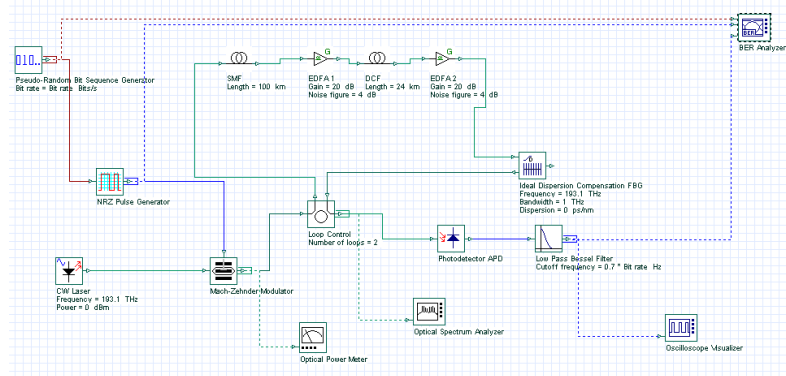
If the incident light has two polarization components, due to refractive difference between the fast axis and slow axis, the transmit rate of two polarization components will be different. Degree of pulse lengthening can be expressed by different group delay $\Delta\tau$. The impact of dispersion on system performance is also reflected in the optical fiber non-linear effects. Dispersion increased the pulse shape distortion caused by the self-phase modulation dispersion (SPM), the other hand, dispersion in WDM systems can also increase the cross-phase modulation (XPM), four-wave mixing (FWM) and other non-linear effects [6,7].

III. DISPERSION COMPENSATION TECHNOLOGY

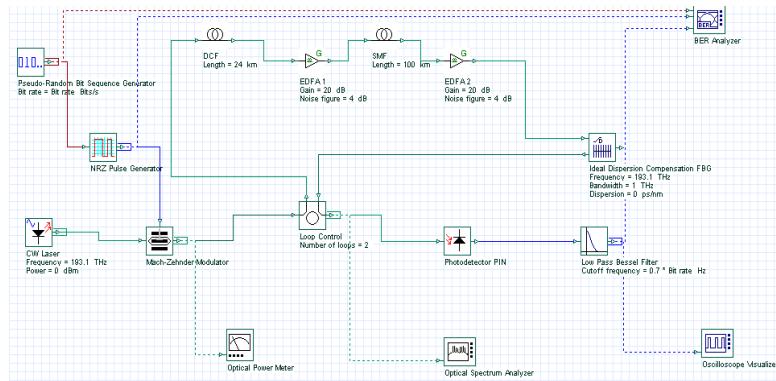
To improve overall system performance and reduced as much as possible the transmission performance influenced by the dispersion, several dispersion compensation technologies were proposed. Amongst the various techniques proposed in the paper, the ones that appear to hold instant promise for dispersion compensation and management could be broadly classified as dispersion compensating fiber (DCF), chirped fiber Bragg gratings (FBG), and high order mode (HOM) fiber [8]. The idea of using dispersion compensation fiber for dispersion compensation was projected as early as in 1980 but, until after the development of optical amplifiers, DCF began to be extensive consideration and study. DCF has become a most useful method of dispersion compensation and has been extensively studied. There is positive second-order and third-order dispersion value in SMF while the DCF dispersion value is negative. So by inserting a DCF, the average dispersion is close to zero. As the local dispersion of higher transmission link, FWM and XPM were ignored only to consider the role of SPM and dispersion.

IV. DISPERSION COMPENSATION SCHEME

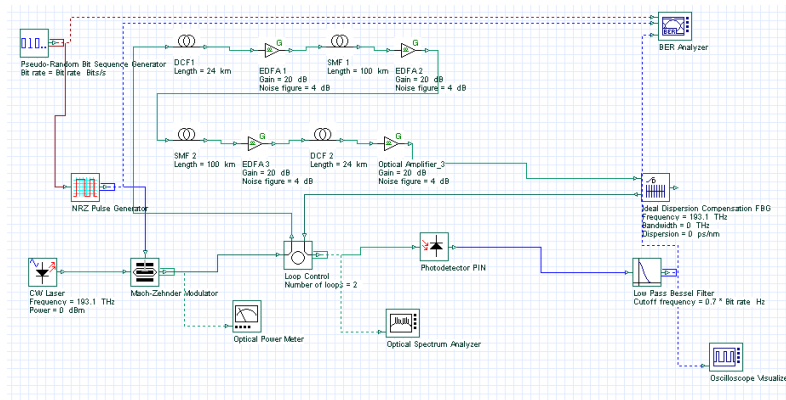
To support a high-capacity wavelength-division-multiplexing (WDM) transmission, the embedded standard single-mode fiber (SMF) should be up rated to overcome the dispersion limit. In this paper dispersion compensating fiber is analyzed with dispersion compensation with the help of fiber bragg compensator. According to virtual position of DCF and single mode fiber, post-compensation, pre-compensation and symmetrical/mix compensation is proposed. DCF Pre-compensation scheme attain dispersion compensation by place the DCF before a certain conventional single-mode fiber, or after the optical transmitter. Post compensation scheme attain dispersion compensation by place the DCF after a certain conventional single-mode fiber, or before the optical transmitter. Symmetrical/mix compensation scheme contains post compensation and pre compensation. Different location on the system will produce different non-linear effects. The simulation of three dispersion compensation system is shown in "Fig. 1,".



(a) Simulation for post compensation



(b) Simulation for pre compensation



(c) Simulation for symmetrical compensation

Fig. 1 Three dispersion compensation scheme

V. RESULT AND ANALYSIS

In optical communication only optical signal to noise ratio (OSNR) could not precisely measure the system performance, especially in WDM systems. Quality factor is a one of the important pointers to measure the optical performance by which to describe the BER.

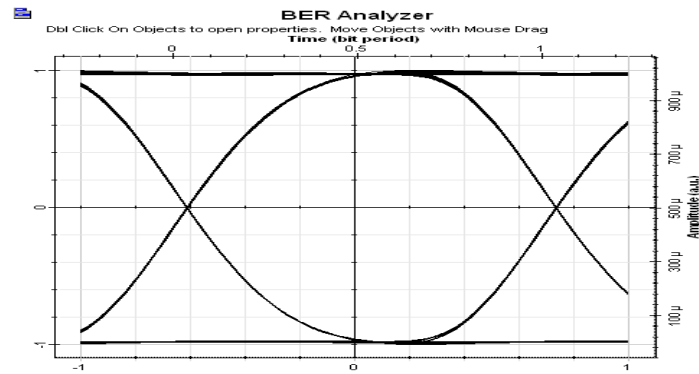


Fig. 2 Post BER (Bit Error Rate) pattern

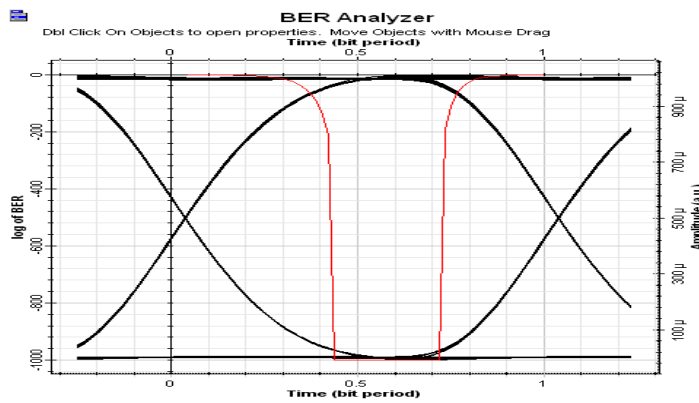


Fig. 3 Post minimum BER (Bit Error Rate) pattern

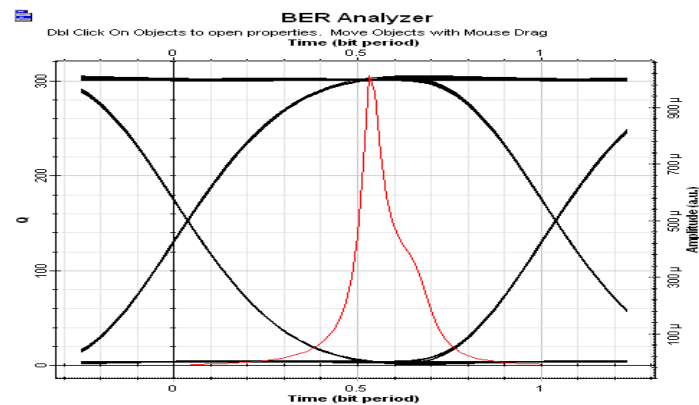


Fig. 4 Post Q- factor

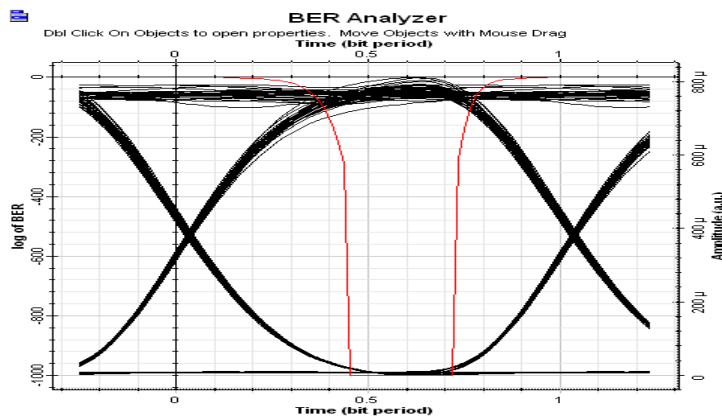


Fig. 5 Pre minimum BER (Bit Error Rate)

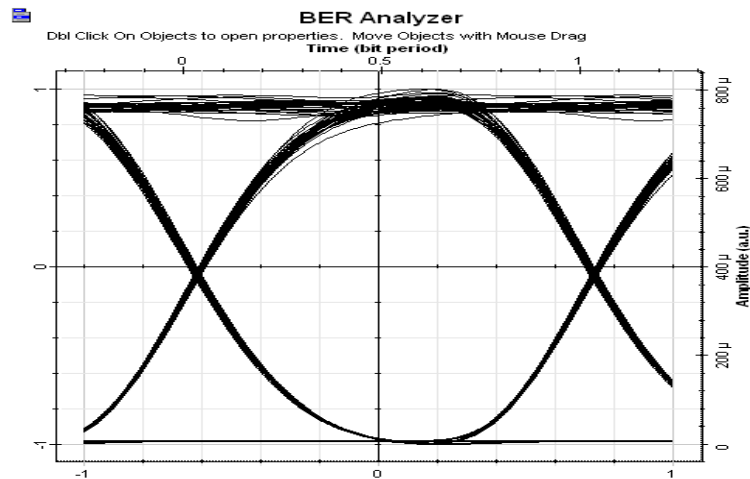


Fig. 6 Symmetrical minimum BER (Bit Error Pattern)

VI. CONCLUSION

On the basis of compared and analyzed the three system simulation results conclusions are as the followings. Using dispersion compensated fiber (DCF) for dispersion compensation in 40Gb/s WDM system is an effective solution. It is observed that the compensation schemes reduced the dispersion appropriately but among them post compensation scheme reduced the collected fiber chromatic dispersion to the maximum possible level. A moderate lesser value of fiber bragg grating dispersion and bigger value of laser average power is favorable to the performance of the transmission system. Variation of the input power launched and compensator dispersion of fiber bragg grating resulted in variation in Q-factor and the corresponding graph showed that at 5 dBm and -0ps/nm the link performance with the regard the Q-factor provides the better result.

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