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Performance Analysis of Dispersion in Optical Communication link Using Different Dispersion Compensation Fiber (DCF) Models

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Abstract: ***Fiber optic dispersion and its effect on optical transmission system are analyzed. The most commonly used dispersion compensation fiber (DCF) technology is studied in this article. Three schemes (pre-compensation, post- compensation, mix-compensation of dispersion compensation) of dispersion compensation with DCF are proposed. In this study, we propose three DCF compensation scheme, pre-compensation, under-compensation and mix compensation scheme. Simulation studies show that mix compensation scheme is the best. It can greatly reduce the influences of the fiber nonlinearity and increase the transmission distance greatly. The simulation model of the WDM based on the Optisystem is presented according to the above principle. The simulation results such as Q factor and BER are given and deeply analyzed. It is found that mix-compensation performance is the best. And the input fiber power is taken about 16 dB, the corresponding BER performance is better.***

Keywords: Dispersion Compensation, Optical Communication Dispersion Compensation Fiber (DCF) Model, BER, Q-Factor

I. INTRODUCTION

The optimal design and application of optical fiber are very important to the transmission quality of optical fiber transmission system. Therefore, it is very necessary to investigate the transmission characteristics of optical fiber. And the main goal of communication systems 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 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 big, about 15-20ps / (40 nm.km-1)[4]. It is easy to see that the dispersion become the major factor that restricts long distance fiber-optical transfers

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II. THE EFFECT OF FIBER-OPTIC DISPERSION ON OPTICAL TRANSMISSION

Dispersion is defined as because of the different frequency or mode of light pulse in fiber transmits at different rates, so that these frequency components or models receive the fiber terminals at different time. It can cause in tolerable amounts of distortions that ultimately lead to errors.

In single-mode fiber performance is primarily limited by chromatic dispersion (also called group velocity dispersion), which occurs because the index of the glass varies slightly depending on the wavelength of the light, and light from real optical transmitters necessarily has nonzero spectral width (due to modulation) [7,8]. Polarization mode dispersion , another source of limitation, occurs because although the single-mode fiber can sustain only one transverse mode, it can carrry this mode with two different polarizations, and slight imperfections or distortions in a fiber can alter the propagation velocities for the two polarizations. This phenomenon is called birefringence. Mode birefringence Bm is defined as the follow Formula:

$$\mathbf{B}m = \frac{|\beta_x - \beta_y|}{k_0} = n_x - n_y \quad (1)$$

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

$$\varphi = k_0 B_m L = \frac{2\pi}{\lambda}(N_X - N_Y)L = (\beta_x - \beta y)L \quad (2)$$

If the Bm is a constant, through the light waves in transmission process the phase difference between its fast axis and slow axis will periodicity repetition. The power exchange also periodically. The length that it leads to a phase difference of 21t or power periodic exchange is called polarization beat length:

$$L_B = \frac{2\pi}{\left|\beta_X - \beta_Y\right|} = \frac{\lambda}{B_m} \qquad (3)$$

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. Because the randomness of fiber birefringence changes, the group velocity of different polarization direction is also random, this will result in the output pulse broadening.

The influence of dispersion on system performance is also reflected in the optical fiber nonlinear 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, four-wave mixing (FWM) and other nonlinear effects[10,11].

III. DISPERSION COMPENSATION SCHEME

The dispersion compensation system in the WDM is studied in this paper. Based on optical transmission equation, considering the various types of nonlinear effects and the impact of EDF A, system simulation models are established. According to relative position of DCF and

single-mode fiber, post-compensation, pre-compensation, mix compensation is proposed. DCF Pre-compensation scheme achieve dispersion compensation by place the DCF before a certain conventional single-mode fiber, or after the optical transmitter. Post -compensation scheme achieve dispersion compensation by place the DCF after a certain conventional single-mode fiber, or before the optical transmitter. Mix compensation scheme is consist of post compensation

and pre-compensation .Different location on the system will generate different nonlinear effects. In order to improve overall system performance and reduced as much as possible the transmission performance influenced by the dispersion, several dispersion compensation scheme were proposed [12]. The Simulation of three dispersion compensation system is shown in Figure 1.

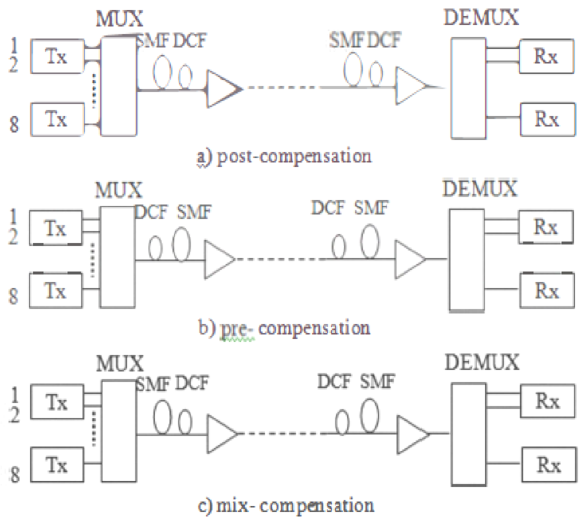

Figure 1 the three dispersion compensation system

Figure 1 (a) shows the post-compensation schemes. The WDM system consists of eight channels, each channel with 40Gb/s. The simulation module includes the transmission module, transmission link and the receiver module. Simulation model use Mach-Zehnder external modulator to modulate the CW Laser. Eight different center frequency wavelength of the light carrier were produced. The center frequency range of Laser is 192.6-194.01 THZ. Transmission code is the DPSK modulation code. 8- channel WDM bandwidth is 80GHZ.Optical fiber transmission link composed of a 160Km. The kind of optical fiber is G.655. Dispersion compensation is achieved with DCF. EDFA is used to compensate the power loss generating by SMF and the DCF signal .Receiver module includes demultiplexer and receiver filters.

Figure 1 b) and Figure l c) respectively show the pre compensation scheme and the mix- compensation scheme. The simulation configuration is as similar as Figure 1 a). The difference is that at the transmitter DCF compensate 80Km of single-mode fiber dispersion in Figure 1 b). In Figure l c), there is a mix- mix- compensation scheme.

IV. RESULTS AND ANALYSIS

In optical communication systems, only optical signal to noise ratio (OSNR) could not accurately measure the system performance, especially in WDM systems. Typically, as a quality factor, Q is a one of the important indicators to measure the optical performance by which to characterize the BER. Figure 2 display the influence of input optical power on the performance of transmission system.

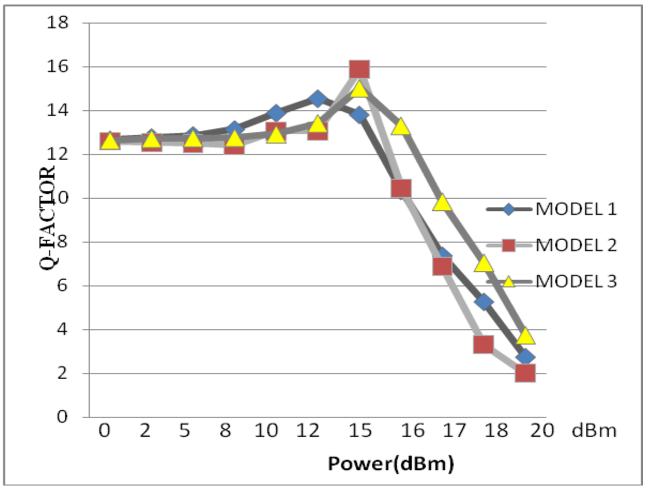

Figure 2 Comparison of transmission power vs Q factor influence of three compensation system

Figure 2 appear that the effect of laser average power is just contrary to the previous situations. A moderate bigger value of laser average power is favorable to the performance of the transmission system. And from the figure we can find that with the input optical power increased to about 9dB, the Q factor increases. When the input optical power approaches 16dB, the Q factor becomes the maximum. When the input optical power is greater than 16dB the quality factor decreased gradually and the error performance is gradually degraded.

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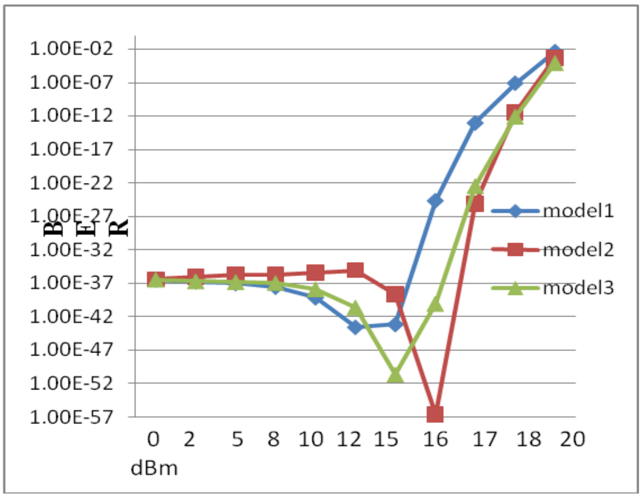

Figure 3 Comparison of transmission power vs BER influence of three compensation system

In fig 3 when the input optical power is greater than 16dB, the nonlinear effect increases rapidly, making the system BER performance is degraded rapidly. As can be seen from Figure 2 &3 in the case of the fiber optical power equal, the quality factor of mix compensation is greater than the two other kinds of dispersion compensation. Through the whole system study found that the performance of mix compensation system is best in the long-distance high-speed WDM systems.

V. CONCLUSION

On the basis of compared and analyzed the three system simulation results conclusions are as the followings. Using DCF for dispersion compensation in 40Gb/s WDM system is an effective solution. The attenuation of DCF fiber is not null. Thus, the attenuation of DCF fiber will produce impairment to the signal quality as well as that of SMF. As the previous discusses, the influence of attenuation can be compensated with optical fiber amplifier such as EDF A. Mix-compensation scheme can greatly reduce the fiber nonlinear effects, this program better than the pre compensation and post compensation program. For this compensation scheme, the effect of laser average power is just contrary to the previous situations. A moderate bigger value of laser average power is favorable to the performance of the transmission system the input fiber power is taken dB, the about 16 corresponding BER performance is better.

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