Simulation Study of Dispersion Compensation in Optical Communication Systems Based on Optisystem

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Abstract. Based on the Optisystem, the simulation model of Optical Communication Systems with Dispersion Compensation is presented. By using FBG, the performance of system in NRZ modulation with M-Z optical external modulator is improved. The parameter setting of the simulation model is presented in detail. The dispersion compensation performances of different pattern is compared through analyzing eye diagrams, input and output signals.

1. Introduction
Since the advent of fiber Bragg grating (FBG) in the late 1980s, a lot of theoretical analysis and experimental studies have been conducted on their characteristics. In recent years, researches have focused on the improvement of fiber grating on the overall transmission performance of fiber optic system[1]. Relevant research methods include simulation research and experimental simulation. OptiSystem is a optical fiber communication system simulation software released by Optiwave company in Canada, which can help users plan, test and simulate all kinds of situations in optical fiber communication systems. From the physical layer devices to the system level optical communication system design and other conditions can be verified by simulation.

In this paper, optical fiber communication system with dispersion compensation is built based on OptiSystem simulation software, and FBG is used to improve the transmission performance of the system. Precompensation, postcompensation and symmetric compensation are used in simulation, and system parameters, waveform and eye diagram are given in detail.

2. Introduction to FBG compensation technology
Dispersion, loss, and nonlinearity in optical fiber communication system are the main factors affecting transmission performance. Mode dispersion mainly occurs in MMF (multi-mode Fiber), and SMF mainly includes material dispersion and waveguide mode dispersion. Common dispersion compensation technologies mainly include distributed coordination function (DCF), optical fiber compensation, chirp, FBG compensation and other methods[2]. In this paper, FBG simulation is used to study the dispersion compensation effect.

The refractive index of FBG can be changed with the spatial distribution of light intensity through certain doping mode, and the refractive index period changes like Bragg grating[3,4]. The dispersion compensation principle of fiber Bragg grating which the specific grating period corresponds to the
specific light reflection wavelength, and the light reflection position of different wavelengths is different, which is applying to form the time delay. Common FBG include chirp FBG and Uniform FBG (UFBG). UFBG is characterized by narrow reflectance spectrum and is often used in optical filtering. CFBG is characterized by a wide reflectance spectrum and can reflect light signals of multiple frequencies, which are mostly used for dispersion compensation [5,6].

At present, the high-speed laser mainly adopts the external modulation mode, which include M-Z (mach-zahnder) waveguide modulator and electric absorption modulator. M-Z modulator is usually made of Lithium Niobate (LiNO3) material, and the Distributed Feedback Laser (DFB) which has good chirp elimination, so M-Z modulator is suitable for long-distance transmission of high-speed systems [7,8].

3. Simulation model and parameter setting

The light source used in the simulation system is the continuous wave (CW) laser diode with a wavelength of 193.1THz. The sequence Generator is used to generate the required digital signal sequence, which is converted into electrical pulse signal by the non-return to zero (NRZ) pulse generator. After passing through the M-Z modulator, the electro-optical effect is loaded on the optical wave to become the optical signal when entering the fiber.

The layout of the postposition compensation simulation system is shown in figure 1. The global parameter is set as 10Gb/s and the sequence length is 8bit. 1550nm window with a typical value of 0.20db/km. The setting of simulation parameters is shown in figure 2 to 4.
Figure 4. FGB parameter setting

Firstly, the system is simulated without dispersion compensation, waveforms and eye diagram are observed. After that, FBG is set to simulate pre-compensation, post-compensation and symmetric compensation. No FBG system, pre-compensation, post-compensation and symmetric compensation system are shown in figure 5-7.

Figure 5. No FBG system

Figure 6. Pre-compensation system

Figure 7. Post-compensation system
4. Simulation result

The fiber input signal, output signal, eye diagram and spectrum analysis of the system before compensation are shown in figure 9. FBG compensated optical fiber input signal and output signal are shown in figure 10 to 12. They are pre-compensation, post-compensation and symmetric compensation respectively.
According to the simulation results, it can be concluded that the uncompensated system has some interference between codes, waveform distortion and unclear eye diagram. It can be observed that signal transmission delay exists in simulation system. After FBG compensation, the eye diagram becomes clear and the waveform distortion is significantly reduced. It can be seen from the spectrum image that FBG has the function of light filtering. Theoretically, when corresponding to a certain input, optical signal to noise ratio (OSNR) transmission performance of pre-compensation, post-compensation and symmetric compensation will be different. In the simulation process, it is also found that under the condition of system setting parameters, the eye diagram opening condition and dispersion compensation effect are analyzed, and the symmetrical compensation performance is the best, followed by the post-compensation.

5. Conclusions
Using M-Z waveguide modulator to construct the transmitter simulation part, the FBG is applied to improve the transmission performance. The simulation adopts the pre-compensation, post-compensation and symmetric supplement methods, and gives the system parameters, waveforms and eye diagram in detail during the simulation. When corresponding to the specific fiber input power, the transmission performance of the system with different compensation methods will be different, which is confirmed by the simulation results of the system. The simulation process has some reference value to the system design.

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