Performance Enhancement of an Optical System Design By Using Fiber Bragg Grating

Sonam[1] and Pulkit Berwal[2]

Abstract— **Dispersion has been a main limiting factor in optical communication transmission system. An optical communication system operating at 10 Gbps based on fiber Bragg grating is presented in this paper with single mode fiber as main channel of transmission. The use of FBG as dispersion compensator shows improved transmission performance in optical fiber communication system. This paper simulates the optical communication system to investigate the effect of dispersion and also measured the performance parameters such as BER, Q factor and eye diagram at 2500 km transmission distance.**

Keywords— **BER, Dispersion Compensation, Eye diagram, FBG and Q factor.**

I. Introduction

In order to make communication over a long distance with larger transmission capacity and longer repeaterless distance, it is very important to restrain the dispersion effect and nonlinear effects such as self-phase modulation (SPM), cross-phase modulation (XPM) and four wave mixing (FWM) [1]-[2]. The optical fiber has some inherent properties like birefringence, which leads to polarization-mode dispersion (PMD). Polarization mode dispersion must be dynamically compensated to avoid performance degradation [3]. In optical communication fiber loss is mainly controlled by erbium doped fiber amplifiers (EDFA). In long haul transmission many technologies have been adopted to reduce the effect of noise, nonlinearity effect, dispersion and also to enhance the quality of optical signal. FBG has been used to enhance the system performance by compensating the dispersion in single mode fiber. This paper describes the design based on single mode fiber, EDFA and FBG for dispersion compensated transmission.

II. System Description

The simulation setup used to compensate the Dispersion that occurs in the fiber while transmitting a signal over an optical link. In this, we compared the compensation at input bit rate of 10 Gbps, with different modulation format and also analysed the system performance at different distances with different input powers. Experimental setup with NRZ format is shown in fig.1 and 2 respectively. First, we design a simulation setup, defined in iteration loop where FBG is used to compensate the dispersion of singe mode fiber. A 10 Gbps signal taken at the input generated by CW lorentzian laser source, modulated by machzehnder modulator and transmitted over a distance of 2500 km [1]-[2]. Single mode non linear fiber, EDFA and FBG has been used to form a dispersion managed transmission link shown in Fig. 1. The quality of system performance has been evaluated through BER and Q-factor.

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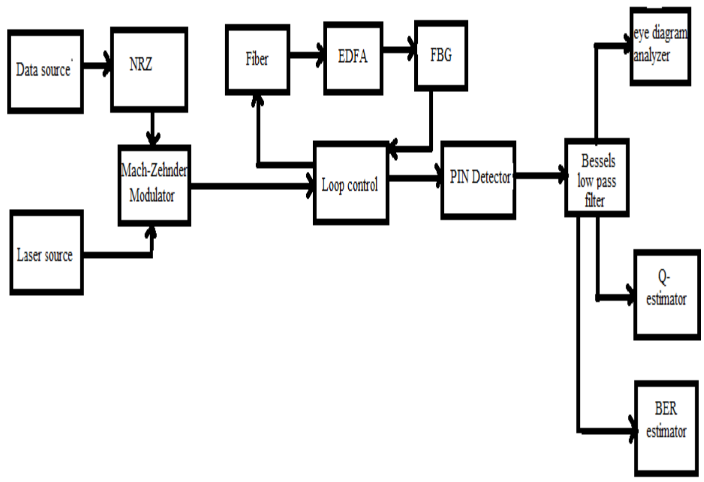

Fig. 1 Simulation setup of dispersion compensation system

Continuous wave laser source of lorentzian type is used here as a input source. This model considers only the phase noise. Laser sources are considered as if they generated a single tone at the nominal center emission frequency of the source. The linewidth is generally neglected in case of CW lorentzian laser. The centre emission frequency is 193 THz. Continuous wave input power used are 0, 5 and 9 dB. Data source is a pseudo-random bit sequence (PRBS) generator or a deterministic logical signal generator of arbitrary level (number of bit per symbol) The signal passed through single mode fiber, amplified by EDFA. This component simulates an EDFA and used just after the fiber to constrain the effect of dispersion and other fiber losses. Several different EDFA component are available, these are flat, fixed gain amplifier to the detailed physical model, fully resolved in the frequency/wavelength domain. EDFA can be used as an optically preamplified receiver for optical signal [4]. This model is used to fixed power and gain along the link. Both the gain and noise figure are wavelength dependent. It specifies many physical parameters, among which the EDFA doped fiber emission, absorption and attenuation spectra and the pumping laser characteristics. The fixed gain EDFA gain model is the simplest model and can be used in different situations where amplification is not a problem. The output from the EDFA is filtered by FBG for dispersion compensation. At the output pin-photodiode has been used to converts the optical signal into electrical signal followed by electrical low pass Bessel filter. An electrical scope with eye display, Q-factor and BER estimation feature has been used at the output [5].

III. Results and Discussion

Following the simulation set up described in section 2, the effect of dispersion has been investigated on long haul optical transmission system. The eye diagrams of the signal for D=16.75 ps/nm-km at 100 km before and after dispersion compensation are shown in Fig.2 and Fig.3 respectively. The

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effect of using FBG as dispersion compensator has been investigated by comparing the two eye diagrams, BER and Q-factor.

The eye diagram has been obtained as a result of simulation, representing the dispersion uncompensated and dispersion compensated signal, results in BER=10^{-5} , Q-factor=11.6 dB and BER=10^{-40}, Q-factor=40 dB respectively. The comparison of BER and Q-factor proved that FBG used as dispersion compensator improved the performance of the system and hence, make it possible to transmit a signal over long distance with less number of losses and other non linearity effects.

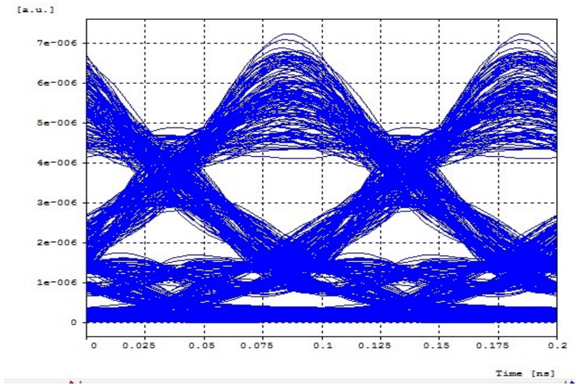

Fig. 2 Eye Diagram obtained before dispersion compensation

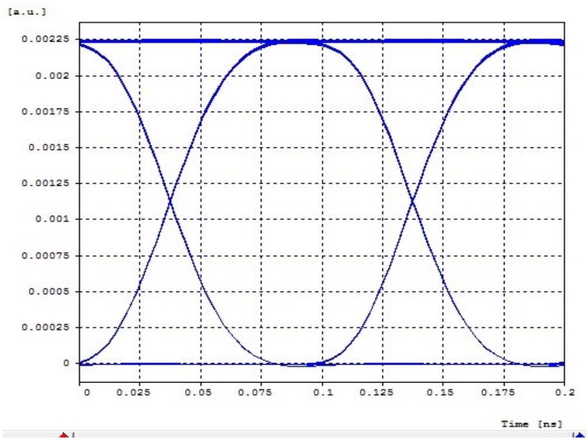

Fig. 3 Eye Diagram obtained after dispersion compensation

The performance parameter has been obtained based on following simulation parameters. The attenuation coefficient has been used for SMF is 0.2dB/km. Value of Dispersion and dispersion slope has been used is 16.75 ps/nm/km and 0.07 ps/nm^2/km respectively. The non linear index coefficient of 2.6x10^{-20} m^2/w has been used. The FBG used in simulation model have uniform grating pattern.

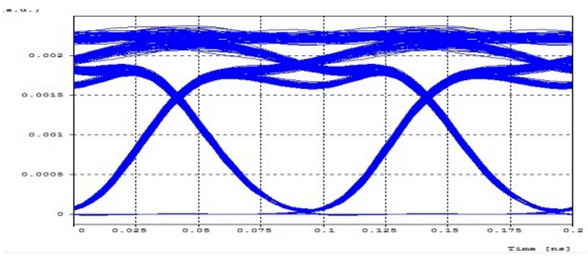

Fig. 4 Eye Diagram obtained at 2500 km transmission distance after dispersion compensation

The eye diagram obtained by electrical scope shown in Fig.4 representing dispersion compensated output. The simulation results in BER=10^{-16} and Q-factor=18.17 dB has been obtained after 2500 km distance. It has been shown that the use of FBG increases the system performance.

IV. CONCLUSIONS

This paper simulates optical communication system using optsim (optical simulation tool). Here, optical communication dispersion compensation based on FBG has been designed. This system shows, BER=10^{-16} and Q =16.3 dB has been obtained by dispersion managed transmission link at based on FBG for long haul transmission.

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