International Journal of Research in Advent Technology, Vol.2, No.7, July 2014
E-ISSN: 2321-9637

Optical System Design Using Fiber Bragg Grating with RZ Modulation Format

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Abstract— Main limiting factor in optical communication transmission is dispersion. An optical communication system operating at 10 Gbps using modulation format of RZ type. Based on fiber Bragg grating optical system shows better performance presented in this paper with single mode fiber as main channel of transmission. To remove dispersion use of FBG as dispersion compensator shows improved transmission performance in optical fiber communication system. This paper simulates the optical communication system using RZ modulation format over long distance investigate the effect of dispersion and also measured the BER, Q factor and eye diagram at 3200 km transmission distance.

Keywords— BER, Eye diagram, FBG and Q factor, RZ

1. INTRODUCTION

The two most important dispersion mechanisms for SMF: chromatic dispersion (CD) and polarization-mode dispersion (PMD). CD is a result of the wavelength-dependency of the refractive index of the fiber. Since CD can be compensated by proper choice of optical fiber. In 10 Gbps system chromatic dispersion always make an influence on optical pulse transmission system. System with RZ format performs better than the system with NRZ format because RZ's nonlinearity tolerance is bigger than NRZ [Jihong, 2008]. 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 [Drummond, 2008].

As the number of channels, data rates and distance increases, certain phenomena such as chromatic dispersion and nonlinearities are grown up. Using special type of fibers such as dispersion compensating fibers (DCF), Dispersion shifted fibers (DSF), Dispersion compensation grating such as FBG and other novel devices effectively compensate dispersion. DCF and Dispersion compensation fiber Bragg grating are more mature than other dispersion compensation technologies. FBG has a good prospect to replace DCF, because of being low loss, compact and polarization insensitive [Liu, 2010].

2. SYSTEM DESCRIPTION

Experimental setup with RZ format is shown in fig.1. One of the mostly developed DCG that we are using these days is Fiber Bragg Gratings (FBG). The word grating in FBG implies the periodic structure – the change in value of the refractive index, the word fiber signifies that the grating is implanted in it and the word Bragg is used signifies the name of the scientist who invented the concept of diffraction grating. All reflected beams of the light combined into one beam so that the Bragg condition is met [Scheiner, 2006].

W. L. Bragg used the crystal structure as a diffraction grating gives the following relation which is called as Bragg condition:

$$2\Lambda\eta_{eff} = \lambda_B \qquad ...(1)$$

Where, λ_B is the Bragg central wavelength, η_{eff} is the effective core refractive index and Λ is the grating period. The grating, selectively reflects only single wavelength and transmit others. These devices are very compact, of length about 10 to 20 cm [Scheiner, 2006].

FBG results in less delay for shorter wavelengths, but more delay for longer wavelength. So that it is very useful device for compensating pulse spread caused by chromatic dispersion in fiber [Scheiner, 2006].

Simulation setup have iteration loop where FBG is used to compensate the dispersion of singe mode fiber. A 10 Gbps signal generated by CW lorentzian laser source, modulated by machzehnder modulator and RZ modulation format, transmitted over a distance of 3200 km. Single mode non linear fiber, EDFA and FBG used to form a dispersion compensation link shown in Fig. 1. The quality of system evaluated through BER and Q-factor.

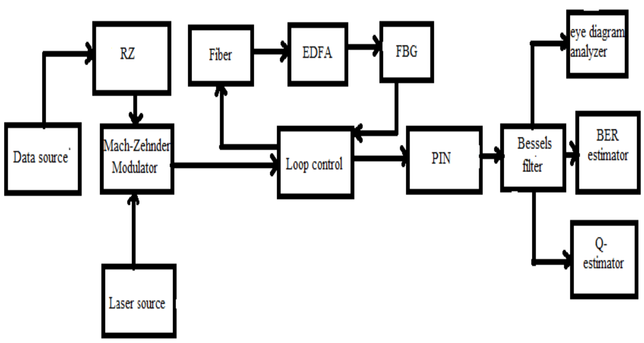


Fig. 1 Simulation setup with RZ modulation format

Continuous wave laser source CW lorentzian laser with centre emission frequency is 193 THz is used. Continuous wave input power used is 5 dB. Pseudo-random bit sequence (PRBS) generator used in Data source [S. Al-Mamun, 2011]. The signal passed through single mode fiber and amplified by EDFA used just after the fiber to constrain the effect of dispersion and other fiber losses. EDFA used as preamplifier receiver. This model is used to fixed power and gain throughout the link. Both the gain and noise figure are wavelength dependent. It specifies many physical parameters, among which the EDFA doped fiber has fixed gain is the simplest model and can be used for amplification in long distance communication. The output from the EDFA is fed to the FBG for dispersion compensation. After FBG pin-photodiode is 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.

3. RESULTS AND DISCUSSION

Following the simulation set up described in section I, 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 effect of using FBG as dispersion compensator has been investigated by comparing the two eye diagrams, BER and Q-factor.

Table 1: Performance parameters at different distances at 10 Gbps, using RZ format at 5 dB input power

Distance (km)	BER	Q-Factor (dB)	Avg. Eye opening [a. u]
100	10^{-40}	40	0.01349
1600	10^{-40}	28.67	0.00896
3200	$4.038*10^{-11}$	16.37	0.007780

Eye diagram obtained before dispersion compensation at 100 km using RZ format with input power of 5 dB, while operating at 10 Gbps is shown and explained as follows:

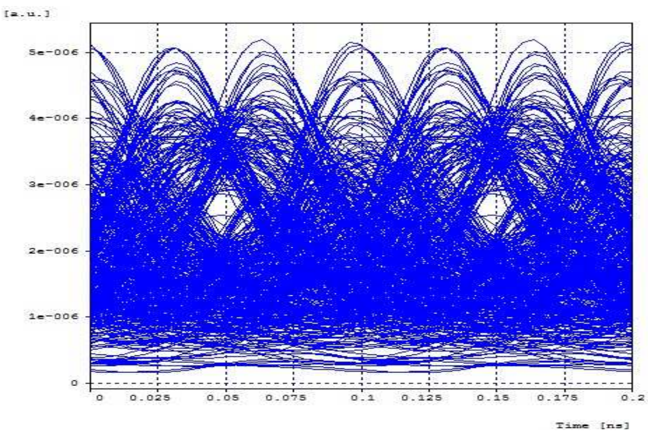
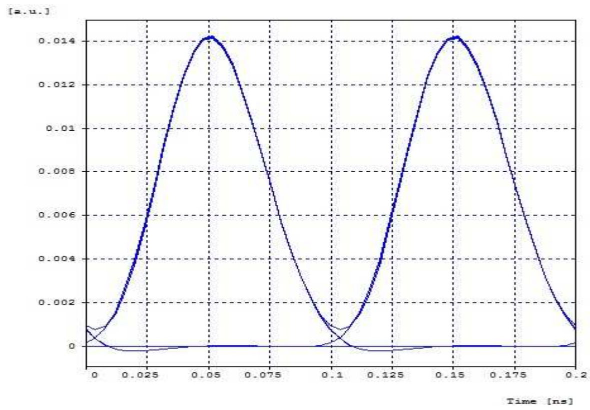


Fig. 2: Eye diagram before dispersion compensation at 100 km

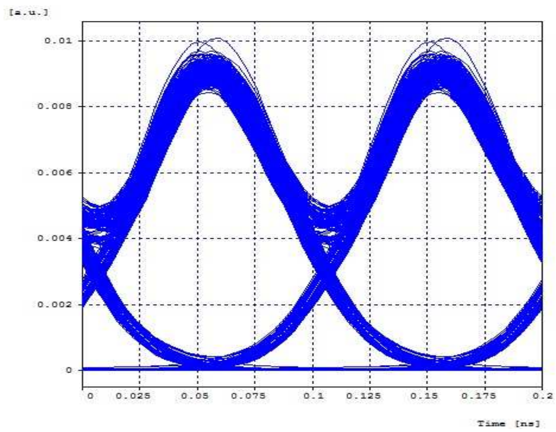
In this dispersion compensation technique, we observed from the fig.2, that the avg. eye opening before dispersion compensation is $1.41*e^{-006}$ a.u, Q-factor is 6.02 dB and BER is 0.02275. Eye diagram is obtained by using electrical scope, while the system operating at wavelength of 1550 nm, input bit rate of 10 Gbps and input power of 5 dB, over a distance of 100 km.

Eye diagrams obtained after dispersion compensation using RZ format over different distances operating at10 Gbps are shown and explained as follows:

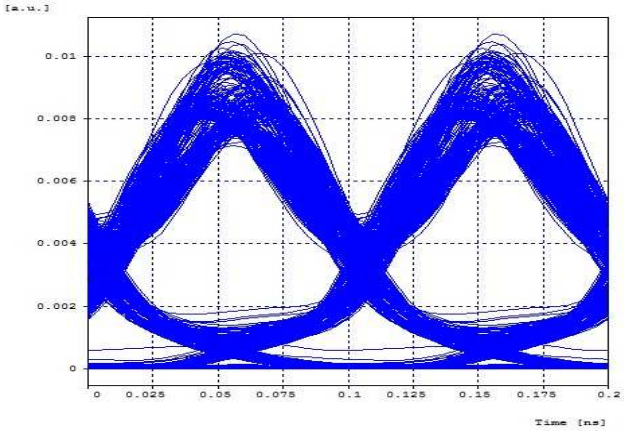
The attenuation coefficient has been used for SMF is 0.2dB/km. Value of Dispersion and dispersion slope has been used is 16.75 ps/nm/km and 0.07 $ps/nm^2/km$ respectively. The non linear index coefficient of $2.6x10^{-20}$ m^2/w has been used. The FBG used in simulation model have uniform grating pattern.



(a)



(b)



(c)

Fig3: Eye diagrams after dispersion compensation at (a) 100 km, (b) 1600 km and (c) 3200 km

Eye diagram after dispersion compensation is obtained at a transmission distance of 100 km, shown in fig.3 (a) and avg. eye opening measured from the eye diagram is 0.01349 a.u. Avg. eye opening at a distance of 1600 and 3200 km, after compensation is also obtained from the eye diagram as shown in fig. 3 (b) and (c), is 0.00896 and 0.007780 a.u, respectively. Dispersion is completely compensated at a distance of 100 km shown by perfect eye diagram in fig. 3 (a). Eye diagrams are obtained at wavelength of 1550 nm, while operating at input bit rate of 10 Gbps and input power of 5 dB. The performance parameter has been obtained based on following simulation parameters.

4. CONCLUSIONS

Optical communication system using optsim (optical simulation tool) is designed with RZ modulation format and on FBG has been designed. This system shows, BER and Q has been obtained by dispersion managed transmission link based on FBG for long haul transmission at different distance with different eye opening, shows improvement in the results as FBG used after compensation BER and Q-factor both shows better values.

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