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Analysis on dispersion compensation using Post FBG with EDFA

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Abstract—We consider that WDM Optical communication network offers very high potential bandwidth and flexibility in terms of high bit-rate transmission. However, their performance slows down due to some parameter like dispersion, attenuation, scattering and unsynchronized bit pattern. In long haul application, dispersion is the main parameter which needs to be compensated in order to provide high level of reliability of service . Fiber Braggs Grating (FBG) is one of the most widely used element to compensate it. In this article, the simulation model of the WDM based on the Optisystem is presented. The simulation results such as Q factor and BER are given and deeply analyzed. This method also offers very high value of Q-factor, reduced BER and noise in long haul optical communication networks.

Index Terms—. Fiber Bragg gratings, optical fiber dispersion, optical filter, dispersion compensation, WDM network.

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1 INTRODUCTION

Dispersion is the main performance limiting factor in optical fiber communication. Dispersion greatly hampers the performance of optical fiber communication. Due to dispersion, broadens optical pulse as they travel in single mode fiber. Limiting the ultimate data rate supported by fiber which causes spreading and overlapping of chips and degrades system performance due to increase inter chip interference and reduced received optical power. So if dispersion can be minimized then a further performance can be obtained from optical fiber communication. There are a lot of methods of dispersion compensation. Post Fiber Bragg Grating with chirp is one of these[1]. When a pulse travels through an optical fiber due to dispersion it becomes broadened. The dispersion is proportional to the length of the fiber. If the length is increased the width becomes bulk and the magnitude reduces[2].

2 METHOD OF DISPERSON COMPENSATION

Dispersion can be minimized by different methods in optical communication system. It can be compensated by using fiber grating, different optical amplifier, different modulation techniques and dispersion compensation fibers. In this paper we are using fiber bragg grating for recovering the dispersed signal[6][7]. The FBG can be placed in on before and after the optical fiber, here we are placing FBG after the optical fiber cable. The simulation is done on different colors of light.

3 DESIGN OF WDM SYSTEM USING POST FBG CHRIP

Figure 1 shows the WDM system using post FBG with chirp schemes. The WDM system consists of four channels, each channel with 40Gb/s. The simulation module includes the transmission module, transmission link and the receiver module. Simulation model use Mach-Zehnder modulator to modulate the CW Laser. Four different center frequency wavelength of the light carrier were produced. The center frequency range of Laser is 192.1-194.4 THZ. Transmission code is the NRZ modulation code. 4- channel WDM bandwidth is 80GHZ.Optical fiber transmission link composed of a 80Km[3]. Dispersion compensation is achieved with FBG with chirp. EDFA is used to compensate the power loss generating by SMF. Receiver module includes demultiplexer and receiver. The received signal can be examine by BER analyzer. Fiber Bragg Grating with following properties has been used: frequency 193.1 THz, reffective index =1.45, chirp function= Linear and linear parameter 0.0001 longer measurement time usually suffer from a crucial drawback – they are critically sensitive to temperature drifts. The thermal expansion coefficient of silica fibers is small ($\alpha \approx 8\times10{-}7$ per K), however, the refractive index of silica fibers may vary with temperature significantly, with thermo-optic coefficient $\delta n/\delta T \approx 1\times10{-}5$ per K 2[8]. In order to assess the influence of the ambient temperature drifts, we measured repeatedly the interferogram at one wavelength during several hours, i.e. a period sufficiently longer than the time needed for the dispersion measurement. The fiber under test was a 1 m long piece of Corning SMF28e fiber. Simultaneously, the ambient temperature was recorded. The standard deviation of the measured ensemble of interferogram's centre positions was found to be 3 µm. It corresponds to the accuracy of 10 fs of the group delay determination. The ambient temperature during the measurement varied by 1.2 °C around 23 °C. When special precautions were made to maintain constant temperature (± 0.1 °C) we obtained the interferogram's centre position with 0.5 µm standard deviation (i.e., group delay accuracy of 1.7 fs). This accuracy is better than that expected due to temperature drift of the refractive index of one meter long optical fiber[4][5]. It can be explained by elongation of the optical rail of the VODL made of cast-iron with thermal expansion coefficient of $\alpha \approx 9\times10{-}6$ per K that partially compensates the temperature drift of the fiber under test[9].

4 DISPERSION COMPENSATION BY EDFA

The basic layout used in each layout considers one Erbium-doped fiber stage setup in a co-propagating pump scheme. Erbium Doped Fiber model was used in this simulation. A single input signal operating in the C-band wavelength range is set in the laser source where small and large signal inputs are considered in the simulations. For each design layout we have three graphs showing the Output Signal Power, Gain, and Noise Figure versus the Sweep Parameter[10]. The components settings can be modified and the simulations repeated in order to analyze the differences observed in the amplifier performance as a consequence of the change in parameter settings. The absorption and emission cross section, input parameters which are critical in the numerical solution of coupled rate and propagating equations, are displayed in Erbium doped fiber component. Figure 2 shows the cross-section file used in this project file. The cross section input files are characteristic to a specific fiber as well as the fiber dimensions specified in the Er doped fiber dialog box component, shown in Figure 3. However, it is interesting to change some fiber specifications in order to evaluate how it can modify the calculated results.

5 SIMULATION FOR DISPERSION MESUREMENT AND RESULT ANALYSIS

In this Section we show an example of a maximization procedure. We will optimize the launch power and DCF length to maximize the Q factor at the receiver. Upgrading an existing noise-limited fiber plant requires an increase in launched power, which in turn brings the fiber nonlinearities. It has been shown that nonlinear return to zero (RZ) coding offers significant advantages for high bit rate transmission systems . Because the fiber dispersion and Kerr nonlinearities balance each other in this case, the launched power is not limited by self phase modulation (SPM). But this configuration requires careful selection of launch power and dispersion compensating fiber (DCF) length. Figure 2 shows the project layout. SMF fiber parameters are as follows: Attenuation is 0.171 dB/km, dispersion is 17.7 ps/nm/km, effective area is 80 micron square, $n_2 = 2.7\times10^{-20}$ m^2/W, length is 100 km. DCF fiber parameters are as follows: Attenuation is 0.6 dB/km, dispersion is -80 ps/nm/km, effective area is 30 micron square, $n_2 = 3\times10^{-20}$ m^2/W, length is 100 km. Bit rate is 10 Gbps, 7th order PRBS bit sequence and Gaussian beam profile is used. The receiver sensitivity is -17 dBm. The receiver sensitivity is -17 dBm. An attenuator is used to find the power penalty.Q factor and minimum BER is shown in figure 2 and 3 respectively. Attenuation of the attenuator is initially set to 0 when Figure 4 shows the eye diagram after 100 km of propagation with optimum parameters when NRZ modulation format is used. The obtained results agree well with the experimental findings of[11] and [12]. Furthermore, comparing the Q factors at optimum points shows that, in fact RZ modulation can tolerate more distortion and reach longer transmission distance Fig 4 shows BER of system and detailed result is shown in table 1.

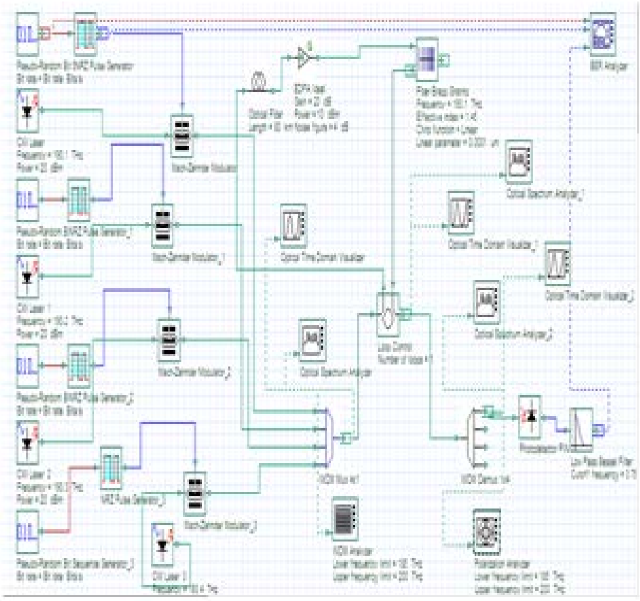
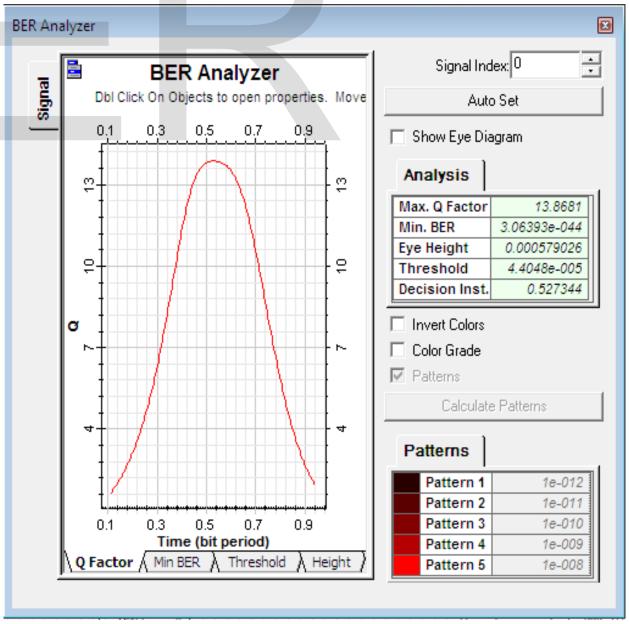


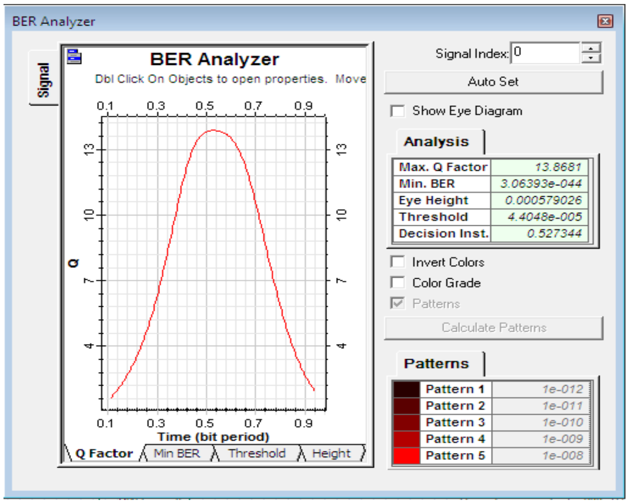
Fig 1- Project layout for simulation



Max. Q Factor	13.8681
Min. BER	3.06393e-044
Eye Height	0.000579026
Threshold	4.4048e-005
Decision Inst.	0.527344

■	Pattern 1	1e-012
■	Pattern 2	1e-011
■	Pattern 3	1e-010
■	Pattern 4	1e-009
■	Pattern 5	1e-008

Fig 2- Q Factor by using FBG



Signal Index: 0

☐ Show Eye Diagram

Max. Q Factor	13.8681
Min. BER	3.06393e-044
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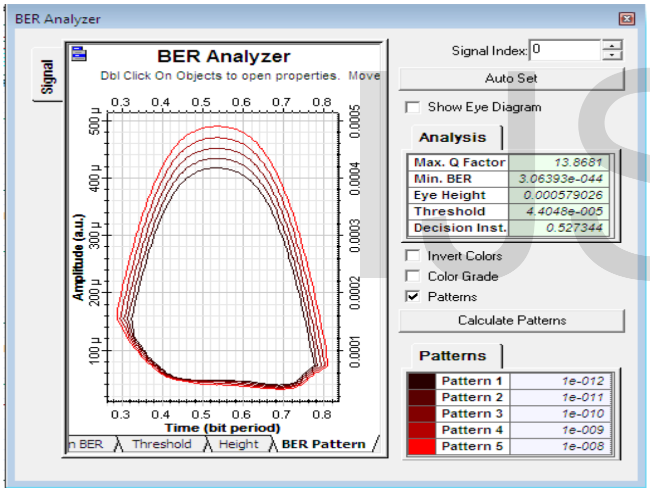
☐ Invert Colors
☐ Color Grade
☑ Patterns

Pattern 1	1e-012
Pattern 2	1e-011
Pattern 3	1e-010
Pattern 4	1e-009
Pattern 5	1e-008

Fig 3-Min BER by FBG



Signal Index: 0

☐ Show Eye Diagram

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☐ Invert Colors
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Pattern 1	1e-012
Pattern 2	1e-011
Pattern 3	1e-010
Pattern 4	1e-009
Pattern 5	1e-008

Fig 4-BER pattern

Table 1: Result analysis of dispersion compensation using FBG with chirp after WDM MUX and after WDM DMUX

Parameters	**Result after WDM MUX**	**Result after WDM DMUX**
	Output: Optical Signal	Output1: Optical Signal
Dispersion at 193.1 THz	2.16587e+008 ps/nm	1.19494e+008 ps/nm
Dispersion at 193.2 THz	-1.93163e+008 ps/nm	4.65114e+007 ps/nm
Dispersion at 193.3 THz	3.59741e+007 ps/nm	1.84029e+008 ps/nm
Dispersion at 193.4 THz	6.33977e+007 ps/nm	1.09275e+006 ps/nm
Noise at 193.1 THz	-1.00000e+002 dBm	-6.30476e+001 dBm
Noise at 193.2 THz	-1.00000e+002 dBm	-1.00000e+002 dBm
Noise at 193.3 THz	-1.00000e+002 dBm	-1.00000e+002 dBm
Noise at 193.4 THz	-1.00000e+002 dBm	-1.00000e+002 dBm
OSNR at 193.1 THz	1.16720e+002 dB	5.80452e+001 dB
OSNR at 193.2 THz	1.16728e+002 dB	2.24562e+001 dB
OSNR at 193.3 THz	1.16724e+002 dB	7.16986e+000 dB
OSNR at 193.4 THz	1.16659e+002 dB	0.00000e +000 dB
Power at 193.1 THz	1.67197e+001 dBm	-5.00245e +000 dBm
Power at 193.2 THz	1.67278e+001 dBm	-7.75438e+001 dBm
Power at 193.3 THz	1.67239e+001 dBm	-9.28301e+001 dBm
Power at 193.4 THz	1.66592e+001 dBm	-1.00000e+002 dBm

6 Conclusion

It is shown in this thesis that the recent advances in Fiber Bragg grating technology now allow the realization of a high performance, high speed optical fibers with good in line dispersion compensation. The characteristic of optical fiber is analyzed. The dispersion is computed by sending a NRZ pulses as an input. In this simulation we are observing that the Q factor is 13.8681, Min BER is 3.06393e-044, Threshold is 4.4048e-005 and Eye Height is 0.000579026. The Q Factor is comparatively low then Post DCF and Ideal FBG. Eye Height is comparatively low then Pre, Post DCF and Ideal FBG. In this technique we can see the dispersion in 193.1 THz is reduced from 2.16578e+008ps/ns to 1.19494e+ps/ns, noise is also reducing. OSNR ratio is improved. The power of this signals is decreased this is only one drawback and it can be overcome by using optical amplifier at output side. For 193.2 THz OSNR Improves while dispersion increases power of signal is decrease. We can see these results are not in our favor on for this signal while other signals are received with fine parameters. For 193.3 THz, dispersion is reduced from 3.59741e+007 ps/nm to 1.84029e+007 ps/nm while noise reduces and OSNR improves. For 193.4, dispersion is reduced from 6.33977e+007 ps/nm to 1.09275e+006ps/nm, noise is reduced and OSNR improves.

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