Analysis to Compensate Dispersion in Optical Communication Link Using Chirp Grating

Anandita joy agarwal 1, Mukesh kumar 2, A.K Jaiswal 3, Rohini Saxena 4

1 PG student, Shiats,Allahbad
2 Assistant professor, Shiats,allahbad
3 Head of department, Shiats,Allahbad
4 Assistant professor, Shiats,allahba

Email- anandita25aja@gmail.com

Abstract- Dispersion needs to be compensated to get the best performance of communication system. One of the technique to compensate dispersion is Fibre Bragg gratings. Using advance fabrication techniques and production facilities modulation in gratings and refractive index can be made along the length of the fiber to produce Chirped FBG. This research paper provides an outline of Chirped FBG and stimulations are performed using Optisystem to achieve the best result of transmission system.

Keywords – Chromatic dispersion, Dispersion Compensation Fiber(DCF), Fiber Bragg Grating (FBG), Chirped FBG.

I. INTRODUCTION

Optical fiber is one of the most prominent topic in communication system in today’s era. Not only it helps in increasing the transmission speed but also helps in decreasing the overall cost of the communication system. When the signal is transmitted through fiber at transmitter, some losses are observed in receiver end and as a result data from original signal is lost.

In Single mode fiber (SMF), chromatic dispersion and polar mode dispersion takes place. Chromatic dispersion occurs due to dependence of group index N\textsubscript{g} to wavelength. Erbium doped fiber amplifier can be used to compensate dispersion in optical system. Also, chromatic dispersion can be compensated by dispersion compensation fiber and fiber Bragg gratings. DCF compensation needs very high negative dispersion coefficient with DCF’s to compensate dispersion in a narrow band frequency. This increases the overall losses nonlinear effects and the cost of the optical communication system. FBG is another method to compensate dispersion. In this, propagated light which satisfies the Bragg condition is resonated by grating structure and reflected and thus we get only a small part of the signal and rest all goes out of the fiber. So FBG’s which compensate the dispersion by the recompression of an optical signal for different architecture of FBG’s have to be introduced It also gives low losses and decreases the cost of the transmission system. Using advance technique the period of grating can be modulated to produce chirped FBG. As the period of grating changes along the axis, different wavelengths are reflected by different parts of grating, and therefore are delayed with different time intervals. Final effect is compression in incident pulse and can be appropriate to compensate chromatic dispersion in a communication link. Advantages of chirp FBGs than other suggested types are low internal lose nonlinear effects and cost efficiency.

II. DISPERSION

A. Chromatic dispersion:

Chromatic dispersion occurs in single mode fiber. It occurs due to the inherent property of silica fiber i.e refractive index varies with wavelength. Therefore, different wavelength channels will travel at slightly different speeds within the fiber. This results in a spreading of the transmission pulse as it travels through the fiber. Hence chromatic dispersion can be referred as a phenomenon which is created due to the dependence of group index to wavelength. Spreading of pulses leads to missing of some data which needs to be minimized so that original data can be attained. The original data can be attained by various dispersion compensation methods.
Analysis to Compensate Dispersion in Optical Communication Link Using Chirp Grating

B. Compensation method to compensate dispersion:
The term dispersion compensation refers to the process of designing the fiber and compensating element in the transmission path to keep the total dispersion to a small number. In generalized form dispersion compensation can be referred as the control of overall chromatic dispersion of the system. There are basically two types of dispersion compensation method namely dispersion compensation fiber (DCF) and fiber Bragg gratings (FBG). DCF needs very high negative dispersion coefficient to eliminate positive dispersion coefficient. Hence the overall cost of the system is increased and also the non-linear effect is increased. It also has high insertion loss. On the contrary FBG is a reflective device composed of an optical fiber that contains a modulation of its core refractive index over a certain period length. Using FBG is a promising approach because they are passive optical component fiber compatible, having low insertion losses and costs.

C. Fiber Bragg gratings:
Hill in 1978 demonstrated the first in-fiber Bragg grating. Fiber Bragg gratings are created by fabricating or scribing the periodic variation of refractive into the core of a special type of optical fiber using intense ultraviolet(UV) source such as UV laser. FBG has a very narrow operating window. FBG is a reflective device composed of an optical fiber that contains a modulation of its core refractive index over a certain length. The Grating reflects light propagation through the fiber when its wavelength corresponds to the modulation periodicity. The reflected wavelength ($\lambda_B$) is called the Bragg wavelength, and defined by the relationship:

$$\lambda_B = \frac{2n\Lambda}{\Lambda},$$

where $n$ is the effective refractive index of the grating in the fiber core and $\Lambda$ is the grating period.

Using fiber Bragg gratings for dispersion compensation is a promising approach because they are passive optical component fiber compatible, having low insertion losses and costs. If some modifications are made to gratings of fiber Bragg gratings a better performance can be achieved. Gratings that have a non-uniform period along their length are known as Chirped FBG. Principle operation of FBG is shown in figure 3.
D. Chirped Fiber Bragg gratings:

The method of chirped FBG to compensate dispersion was introduced by Quellete and later was demonstrated by Williams et al. Chirped FBG can be defined as an in-filter broadband reflective optical fiber. Using advanced fabrication technique and production facilities, grating period and refractive index modulation depth along the length of the FBG can be precisely controlled to produce Chirped FBG.

Working of chirped Fiber Bragg gratings to compensate dispersion:

A dispersion light pulse with a longer wavelength and the shorter wavelength is incident on the chirped fiber Bragg grating. The longer wavelength light is reflected near the front of grating whereas the shorter wavelength light is reflected back. Therefore the shorter wavelength delayed related to longer wavelengths. The chirped grating can be designed so that the entire wavelength in the light pulse comes out at the same time and the dispersion in the optical pulse is equalized or nullified. Chirped FBG not only helps in minimizing the cost of the transmission system but also has low loss insertion.
Block Diagram to simulate transmission System

The proposed Block diagram to simulate transmission system without FBG and with FBG is shown in figure 4(a) and figure 4(b) respectively.

Figure 4(a): A block diagram of transmission system using FBG

System 1 includes a pseudo random sequence generator, non-return-zero (NRZ), a continuous wave (CW) laser with frequency 193.1 and output power 1MW and a Mach Zehnder modulator with 30dB extinction. The signal gets modulated with a non-return-zero pseudo random sequence in Mach Zehnder modulator. The output of system 1 is fed into optical fiber whose length is 15km and 30km, dispersion is 17ps/km/nm, dispersion slope is 0.050pm/nm²/km, and attenuation index is 0.20km. Then the dispersed wave goes into a chirp fiber bragg grating from where a better signal is achieved. The parameters used in chirp FBG are frequency, effective refractive index, length of grating, apodization function, tanh parameter, chirp function. Linear parameter and their values are 193.1THz, 1.45, 6, Tanh, 4, linear and 0.0001 respectively. The signal is then amplified in EDFA amplifier which has a gain amount of 6dB. The amplified signal passes through System 2 and we get output electrical signal. System 2 consist of a photodector (PIN) and eye diagram anlyzer. Figure 5(a) shows the eye diagram of the signal propagating over 15km and 30 km without using Chirp FBG. It shows the dispersion in output signal. As soon as the dispersion is observed, chirp FBG is added to the system to compensate the dispersion. Figure 5(b) shows the eye diagram of the signal propagating over 15km and 30km using Chirp FBG. Also figure 6(a) and 6(b) shows the graph of length of fibre vs total power.
On comparing the graphs it can be observed that when chirp FBG is added to the system power gradually decreases. The parameters of the graph is given in Table 1 and Table 2.

Length of the fibre 15km

length of the fibre 30 km

Figure 5(a) The eye diagram of the signal propagating over 15km and 30km without using Chirp FBG.

Length of the fibre 15km

length of the fibre 30 km

Figure 5(b) The eye diagram of the signal propagating over 15km and 30km using Chirp FBG.
Analysis to Compensate Dispersion in Optical Communication Link Using Chirp Grating

Table 1: Parameters of length of fiber and power without FBG

<table>
<thead>
<tr>
<th>Length of the fibre (km)</th>
<th>Power(dBm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>-25.272</td>
</tr>
<tr>
<td>15</td>
<td>-27.223</td>
</tr>
<tr>
<td>20</td>
<td>-29.202</td>
</tr>
<tr>
<td>25</td>
<td>-31.102</td>
</tr>
<tr>
<td>30</td>
<td>-33.198</td>
</tr>
</tbody>
</table>

Figure 6(a): A graph showing length of fibre vs total power without FBG

Table 2: Parameters of length of fiber and power with FBG

<table>
<thead>
<tr>
<th>Length of the fibre (km)</th>
<th>Power(dBm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>-32.427</td>
</tr>
<tr>
<td>15</td>
<td>-34.362</td>
</tr>
<tr>
<td>20</td>
<td>-36.540</td>
</tr>
<tr>
<td>25</td>
<td>-38.308</td>
</tr>
<tr>
<td>30</td>
<td>-40.359</td>
</tr>
</tbody>
</table>

Figure 6(b): A graph showing length of fibre vs total power using FBG

IV. CONCLUSION

Chromatic Dispersion in optical fibre needs to be compensated to get better result and to reduce the cost of the fibre. It is found that chromatic dispersion can be compensated by adding chirp FBG in the transmission system. Not only it helps in reducing the losses but also minimizes the cost of the system. It can also be seen that when chirp FBG is added to the system total output power also decreases.
REFERENCE