A Review Paper on Dispersion Compensation Methods

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Abstract: *In this paper discussion is on what improvements are on the horizon in terms of fiber development. As long–haul communication requirement is maximum bandwidth, minimum deterioration of signal and minimum attenuation. In case of optical amplifiers, attenuation is no longer the main issue. But still there is problem of dispersion. With Dispersion optical fiber's performance degrades. Research was carried on how dispersion can be compensated. Using two techniques DCF(Dispersion Compensation Fiber) and FBG (Fiberbragg grating) dispersion can be Minimized. EDFA amplifiers have boosted the capacity of existing systems that's why they are used in the link. Simulation software is a very rapid, efficient and economical way to design and analyzefiber opticalsystems.*

Keywords: Dispersion, FBG, DCF,EDFA

1. INTRODUCTION

In single mode fibers[3], intermodal dispersion is absent simply because energy of the injected pulse is transported by a single mode. However, Pulse broadening does not disappear altogether. The Group velocity associated with the fundamental mode is frequency dependent because of chromatic dispersion. Different spectral components of the pulse travel at slightly different group velocities, knows as group- velocity dispersion(GVD), intramodal dispersion.

Discussions on these topics will tell about how GVD limits the lightwave systems having single mode fibers. Mechanism that causes dispersion in a singlemode fiber is chromatic dispersion and Polarization-mode dispersion(PMD). Intramodal dispersion has two contributions, material dispersion and waveguide

Dispersion . In single mode fiber where intermodal dispersion does not exist and material dispersion is very small.

2. DISPERSION

Dispersion is characterized as pulse spreading in an optical fiber. As a pulse of light spreads through a fiber,

components, for example, numerical aperture, core diameter, refractive index profile, wavelength, and laser line width make the pulse widen. Dispersion increments along the fiberlength.

The general impact of dispersion on the performance of a fiber optic framework is known as Intersymbol Interference (ISI). Intersymbol interference happens when the pulse spreading caused by scattering causes the output pulse of a framework to overlap, rendering them undetectable.Dispersion is by and large partitioned into three classifications: modal dispersion, chromatic dispersionand polarization mode dispersion.

2.1 Modal Dispersion

It causes pulses to spread out as they travel along the fiber,the more modes the fiber transmits, the more pulses spread out. The arrival of different of the light at different times is called Modal dispersion.

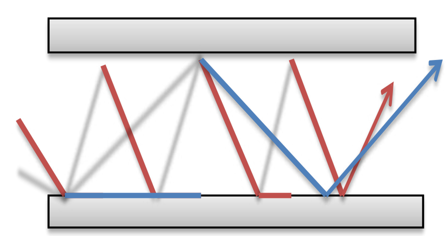

Fig-1 : Modal Dispersion

2.2 Chromatic Dispersion (CD):

It is associated with wavelength dependent pulse spreading due to the fact that different wavelengths of lightpropagate at slightly different velocities through the fiber because the index of refraction of glass fiber is awavelength-dependent quantity; different wavelengths propagate at different velocities.Chromatic Dispersion (CD) that causes pulse broadening depending on wavelength. Chromatic dispersion causes pulse broadening and Bit errors.

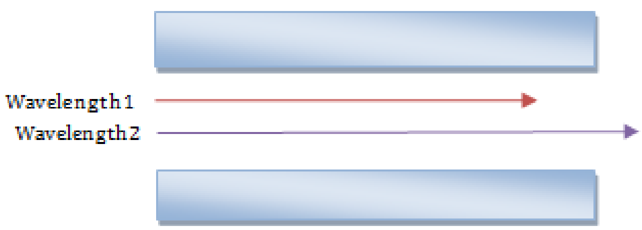

Fig-2 : Chromatic Dispersion

Chromatic dispersion consists of two parts: material dispersion and waveguide dispersion

2.3 Material Dispersion[6]

It is caused when a light travels within a medium whose refractive index is wavelength dependent, the light will experience material dispersion regardless of whether the medium is enclosed or not.As it depends on the material and can't be changed.

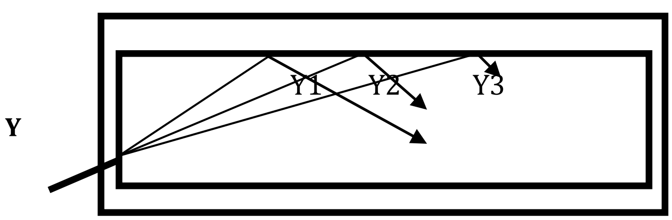

Fig-3: Material Dispersion

2.4 Waveguide Dispersion

It occurs when light travels with in an enclosed medium. Waveguide dispersion depend on the refractive index profile and can be changed. It can be used to produce dispersion-decreasing fibers in which GVD decreases along the fiberlength

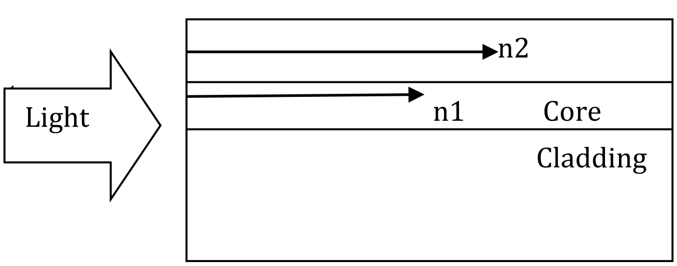

Fig-4 : Waveguide Dispersion

2.5 Polarization Mode Dispersion (PMD)

It happens because of birefringence along the length of the fiber that makes diverse polarization modes go at various rates which will prompt revolution of polarization introduction along the fiber . Polarization Mode Dispersion (PMD) that causes pulse broadening depending on polarization.

3. DISPERSION COMPENSATION TECHNIQUES

3.1 DCF (Dispersion Compensation Fiber)

Too much dispersion in a system leads to power penalty and poor quality of service. Users want more bandwidth and dispersion limits bandwidth in optical fibers.

In Chromatic dispersion[1],it gives an opportunity to compensate for dispersion along the entire span of the fiber-optic link. In DCF the positive dispersion can be compensated by inserting a piece of fiber with a negative dispersion characteristic so that the total dispersion of the link will be almost zero.

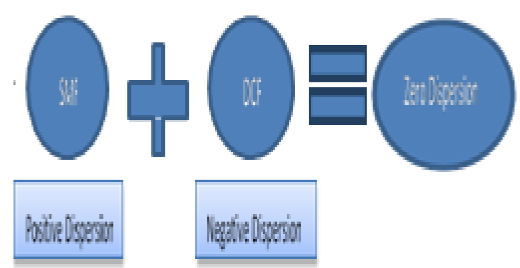

Fig-5 : Dispersion Compensating Fiber

DCF compensation needs very high negative dispersion coefficient with DCF's to compensate dispersion in a narrow band frequency.
There are three schemes in Dispersion Compensation Fiber

1. Pre Compensation

In Pre compensation[4] DCF is placed before SMF .The designing consists of DCF ,EDFA and SMF. Purpose of EDFA after DCF is that it provides periodic amplification. Dispersion Parameter is expressed in ps/nm/km and is in negative.

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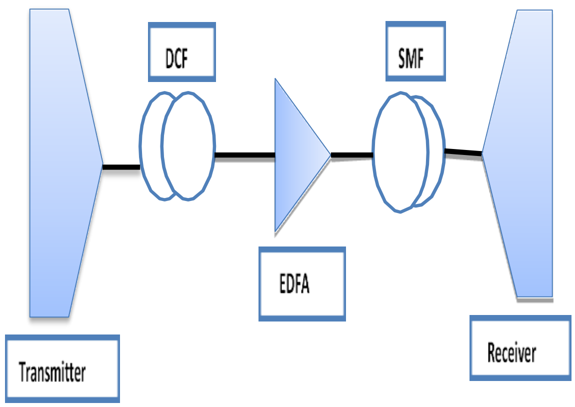

Fig-6: Pre Compensation

2. Post Compensation

As dispersion causes pulse broadening and pulse distortion. Another compensation is post compensation in which SMF(single mode fiber) is placed before DCF.

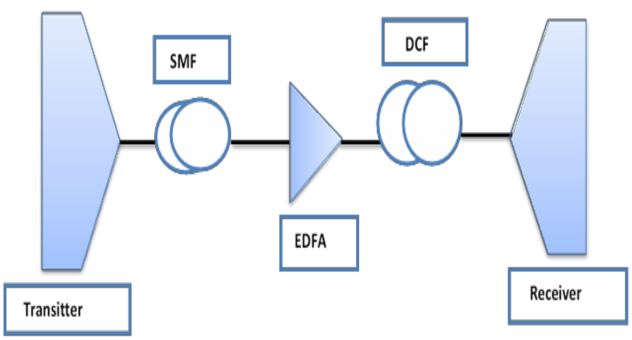

Fig-7 : Post Compensation

3. Symmetric Compensation

In symmetric compensation ,DCF is placed before and after the standard fiber.

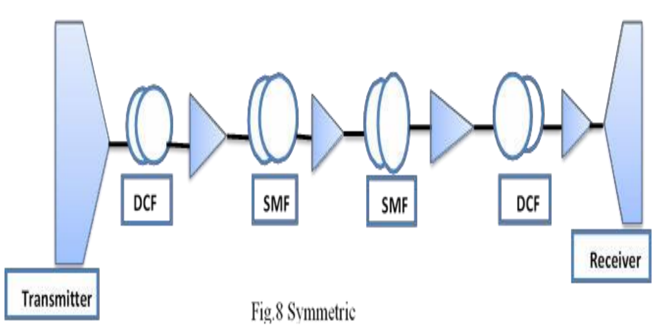

Fig-8: Symmetric Compensation

3.2 Fiber Bragg Grating (FBG)

It is the another dispersion compensation technique. It acts as an optical filter because of existence of a stop band. Fiberbragg grating acts as a reflection filter.FBG is a type of distributed Bragg reflector which reflects a particular wavelength of light and transmits all others. A Fiber Bragg Grating[2] is either used as an inline optical filter to block certain wavelength or as a wavelength specific reflector. There is a periodic variation of refractive index in Bragg grating within the propagating medium .FBG provides a wide variety of applications, such as notch filtering ,dispersion compensation, channel equalization, real time signal processing, etc.in optical communications.

FBG is used in two configurations,

1. Pre compensation

It defines when the FBG is placed at the starting of optical link and before amplifier. Following figure describes the concept of pre compensation.

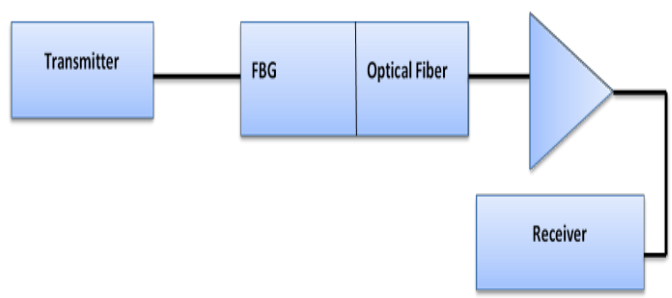

Fig-9 : Pre Compensation

2. Post Compensation

It defines the situation when FBG s placed at the end of optical link. Following figure describes the post compensation.

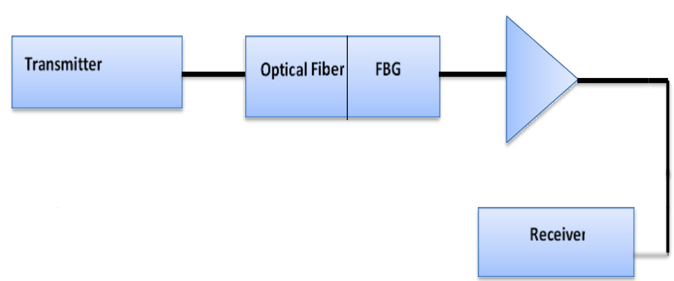

Fig-10 : Post Compensation

4. EDFA (ERBIUM-DOPED FIBER AMPLIFIERS)

The bandwidth of EDFAs is large enough that they have proven to be the optical amplifier of choice. It can amplify light at wavelengths in C band(1530nm-1600nm) and L band(1560nm- 1610nm).where C band is coventional band and L band is Long wavelength band.The EDFA is the enormous change that occurred in the optical fiber communication systems; the loss is no longer major factor to restrict the fiber optic transmission. Gain of an EDFA depends on a number of parameters such as erbium-ion concentration, amplifier length , core radius, and pump power.Performance of EDFA depends on the signal wavelength since both the noise figure and the pump power required to achieve transparency change with the signal wavelength.

5. COMPARISON BETWEEN DCF AND FBG

Table-1 :Comparison between DCF & FBG

Characteristics	**DCF(Dispersion Compensating Fiber)**	**FBG (Fiber Bragg Grating)**
Attenuation	0.8 dB/km	0.2 dB/km
Insertion Loss	High	Low
Non Linear effects	some limitations	No
Construction	Complex	Simple
Overall Cost	High	Low
Bandwidth	Wide band,20nm	Narrow band, 0.1- 5nm

6. CONCLUSION

It is found that Chromatic dispersion can be compensated by choosing an appropriate wavelength equal to the zero-dispersion wavelength .on the other hand, polarization mode dispersion becomes bandwidth limiting factor as there is no such means to exclude PMD. For long haul communication dispersion compensation is necessary. As it is necessary to reduce losses and cost of the system. It is concluded that Dispersion compensation fiber and fiber bragg grating techniques are used as per requirement of the system. EDFA is used as a amplifier in the link as it can operate in C band as well as in L band and boost the system performance. As insertion loss is less in FBG and it also helps in reducing cost of the system. On the other hand DCF increases total losses and cost of the system.

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