New Functionalities for Advanced Optical Interfaces (Role of DCF and Performance Analysis of Different Dispersion Compensation Techniques)

Raghavendra Patidar
Ph.D. Research Scholar

Dr.Hitesh Joshi
Research Supervisor

Abstract:
Dispersion Compensation (DC) and Power Optimization (PO) are highly required parameters in Optical Communication System.
In recent years there has been a lot of work on dispersion-compensating fibers (DCFs), which are being used extensively for upgrading the installed 1310 nm optimized optical fiber links for operation at 1550 nm. Dispersion leads to pulse spreading that causes the output pulses to overlap. Without dispersion compensation, each symbol would be broadened so much that it would strongly overlap with a number of neighboring symbols. Even for moderate broadening, significant inter-symbol interference can strongly distort the detected signal. Therefore, it is essential to compensate the dispersion before detecting the signal.

Keywords: Optical fiber, DCF, WDM system, SMF, PDM

I INTRODUCTION

Optical fiber
In the next generation of light wave systems, high speed data rate like 10 Gb/s or 40 Gb/s per channel is very attractive. In addition, to pack more channels into one single fiber, channel spacing is decreased from 200 GHz to 50 GHz or even smaller. The direct side-effect is linear and nonlinear degrading effects which will be severe in such high-speed light wave systems. The latest advancement needed urgently for reducing dispersion and power optimization, which transmits data and prepared for transmitting messages module onto light waves which uses glass (or plastic) strings (fibers) to transmit. [16]

Dispersion compensation Fiber (DCF)
Compensation of dispersion at a wavelength around 1550 nm in a 1310 nm optimized single mode fiber can be achieved by specially designed fibers whose dispersion coefficient (D) is negative and large at 1550 nm. These types of fibers are known as Dispersion Compensating Fibers (DCFs).DCF for dispersion compensation was proposed in 1980.SMF have positive dispersion and DCF have negative dispersion so overall dispersion is zero. Electronic balance strategies are utilized as a part of technique. Since there is immediate recognition at the receiver, direct contortions in the optical space, e.g. chromatic scattering, are converted into non straight mutilation after optical - to-electrical change. [17]

II DISPERSION

Dispersion is a phenomenon related to the variation in velocity of different frequencies (wavelengths) or different modes. The velocity of different frequencies can be different due to intrinsic properties of the medium or due to dispersive nature of the bound structure like the optical fiber. [1]
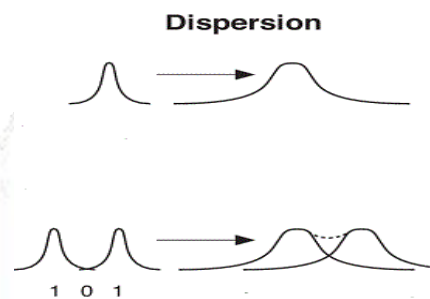

Figure-1

As shown in figure-1 as pulse travels downs a fiber dispersion causes pulse broadening, this limits the data bit rate on a optical fiber.

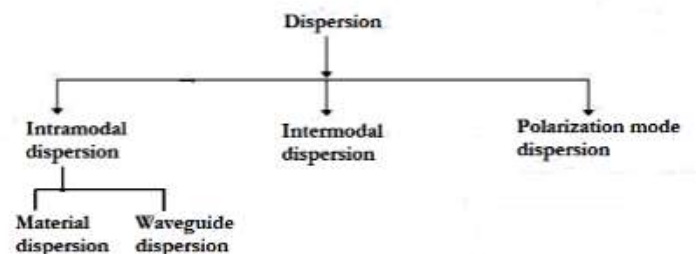Dispersion can be broadly categorized as shown in fig.2

Figure-2

Intra-modal dispersion
In single mode optical fiber different color of light travel at different speed in different material and different waveguide structure. Hence light will exit at different time for each color hence causing Intra –Modal dispersion.

Inter-modal Dispersion
In inter-modal dispersion which occurs in multimode fiber the incoming light signal have different modes of propagation.

Each wave hence will reach at different time at the exit and hence will cause Inter-modal dispersion.

Material dispersion

Material Dispersion takes place due to different speeds of different wavelength in material medium. The long wavelength travel faster than shorter wavelength. As a result of this the narrow pulse of light broadens thus the material dispersion occurs due to spectral width of the light source.

Waveguide Dispersion

Waveguide dispersion, most significant in a single- mode fiber, occurs because optical energy travels in both the core and cladding, which have slightly different refractive indices. The energy travels at slightly different velocities in the core and cladding because of the slightly different refractive indices of the materials. Altering the internal structures of the fiber, allows waveguide dispersion to be substantially changed, thus changing the specified overall dispersion of the fiber. [3]
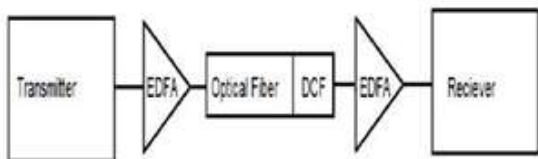
III DISPERSION COMPENSATION TECHNIQUES

Dispersion-compensating fibers (DCF) are important method of dispersion compensation. They operate by insertion of fibers with dispersion of negative slope, high absolute value. Their lengths can be 17-20 km. If Lengths are too high then nonlinear effects causes a problem. They have wide bandwidth suitable for WDM applications (~20nm).[17]

There are basically three schemes that can be used to install a dispersion compensating fiber-pre, post or symmetrical. In pre compensation technique DCF is inserted in the loop before the standard mode fiber as shown in figure no.3 (a). In post compensation technique the DCF is inserted in the loop after the standard fiber as depicted in figure no. 3(b). In symmetrical compensation DCF is inserted both before and after the standard mode fiber as shown in figure no. 3(c). Out of these three schemes symmetrical compensation shows a better performance in compensating dispersion. (a)Pre-Compensation (b) Post-Compensation (c) Symmetric Compensation [3]
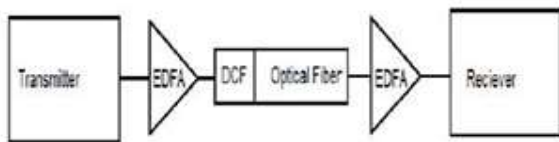
(a)Pre- Compensation

(b)Post- Compensation
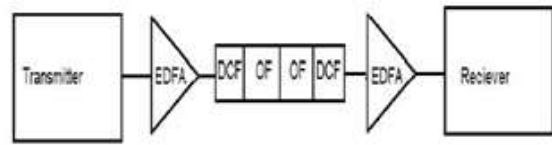
(c) Symmetric Compensation
Figure 3: Different dispersion compensation techniques [4]

IV SIMULATION SET-UP AND DESIGN CONSIDERATIONS

The simulation setup for dispersion compensation has been designed by using Optisystem 7.0 software Simulations of all these three techniques for dispersion compensation.(Pre, post, symmetrical) has been done at 2.5 Gbps data rates. Parameters listed in table no.1&2 have been used in our simulations. In the simulation setup, the transmitter section consists of a pseudo random bit generator which generates random stream of 0's and 1's. The output of pseudo random bit generator is fed to NRZ pulse generator which converts binary data into electrical pulses. Next mach-zehnder modulator (Excitement ratio of 30 db) is used which modulates the signal from output of NRZ pulse generator with a CW laser with central frequency at 193.1 THz. The optical link consists of SMF and DCF along with Erbium doped fiber amplifier. The simulation parameter of SMF and DCF used in the simulations are shown in table no. 1&2. At the receiver side optical signal is transformed in to electrical signal by APD photodiode, output of which is fed to a LPF in order to remove high frequency noise from the received signal. [12]

Table No.1   SMF Parameters

SMF Parameters	Value
Reference Wavelength	1550 nm
Length	150 Km
Attenuation	0.2 db/km
Dispersion	17 ps/nm/km
Dispersion slope	$.08 ps/nm^2 /km$
Differential group delay	0.5 ps/km
PMD coefficient	0.5 ps/km

Table No.2   DCF Parameters

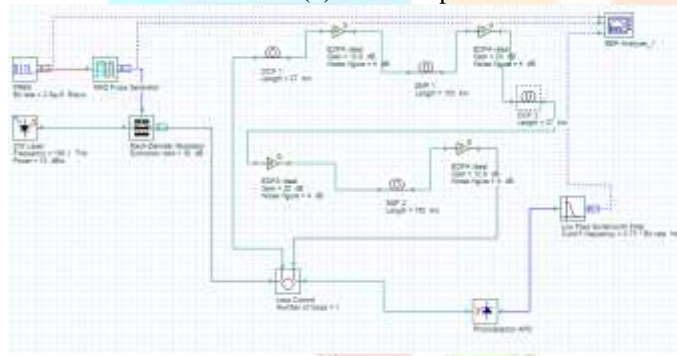| DCF Parameters	Value
Reference Wavelength	1550 nm
Length	27 Km
Attenuation	0.5 db/km
Dispersion	-80 ps/nm/km
Dispersion slope	$.08 ps/nm^2 /km$
Differential group delay	0.5 ps/km
PMD coefficient	0.5 ps/km

The simulation setup used for pre, post and symmetric compensation are shown in Fig no. 4(a), Fig no. 4(b), and Fig no. 4 (c) respectively.
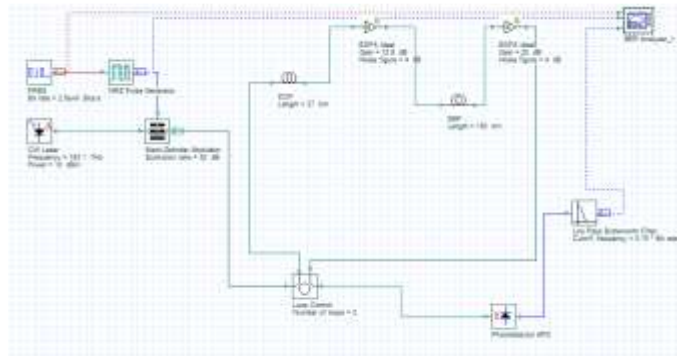
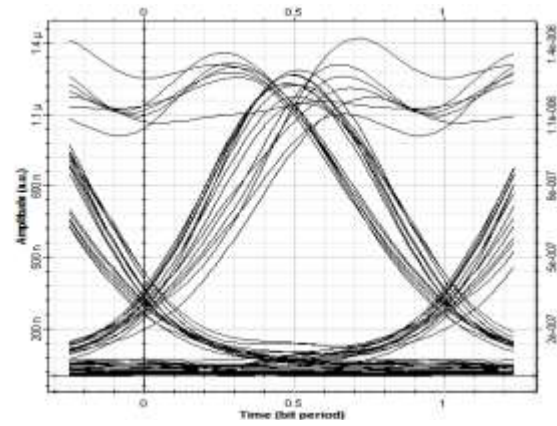

(a) Pre-compensation
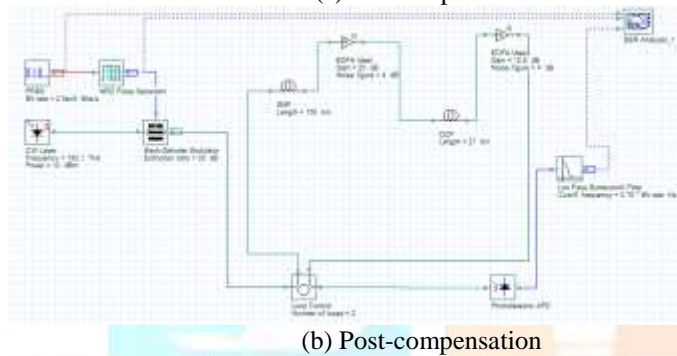
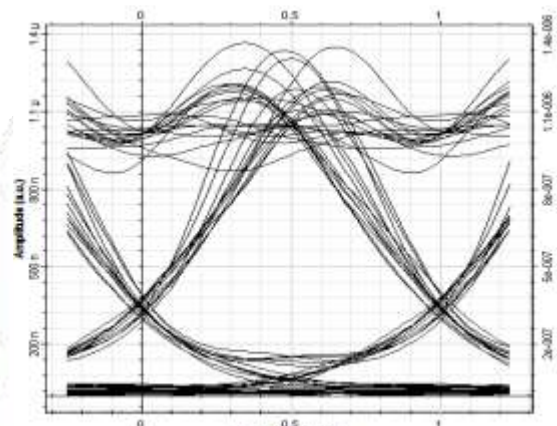(b) Post-compensation

(c) Symmetrical/mix-compensation

Figure 4: Three Dispersion Compensation Techniques
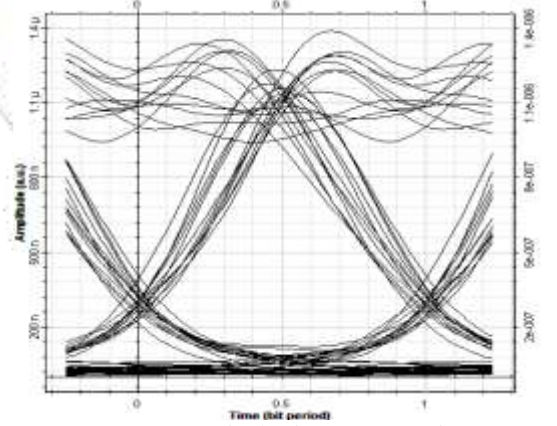
V RESULTS AND ANALYSIS

For simulation and designing we use Optisystem 7.0 simulator, it is an innovative, rapid developing, and powerful software design tool. It helps the users to test and simulate almost all kinds of optical fiber links. The eye diagrams for the three schemes are shown in "Fig.5".

(a) Pre-compensation

(b) Post-compensation

(c) Symmetrical/mix-compensation

Figure 5: Eye Diagrams of Three compensation Techniques

Table No.3 Comparison of three Dispersion Compensation Techniques

Technique	Q-factor (db)	BER	Eye Height	Threshold value

Pre-compensation	10.8486	7.79898e-028	0.00090337	0.00026403
Post-compensation	9.90041	1.64536e-023	0.00086042	0.00022787
Symmetrical-compensation	13.8791	3.04739e-044	0.003109	0.00057569

VI CONCLUSION AND FUTURE SCOPE

CONCLUSION

It has been analyzed that dispersion compensation reduced the dispersion appropriately but among these symmetrical compensation scheme reduced the dispersion maximum. From the above analysis it is clear that Dispersion Compensation Fibers reduce the dispersion as much possible extend. After simulation we observed that the symmetrical-compensation technique is the best dispersion compensation technique than pre and post compensation.

FUTURE SCOPE

It has been concluded that dispersion is the main problem in improving the standards of the fiber communication. Researchers have demonstrated many different techniques to compensate the dispersion in the high speed optical fiber transmission. We can improve dispersion by comparing and analyzing different techniques discussed above. Using optical based software's like OPTYSYSTEM and OPTISIM we can operate different parts of the transmission system using DCF technique such as using higher bit rates with complex WDM systems, we can also test upper optimized limits of the DCF fibers as their lengths and other inherent characteristics. So in future, digital filter can be used with digital signal processing for effective compensation of dispersion.

REFERENCES

[1]   NPTEL Module 5 : Lecture Signal Distortion on Optical Fibers – Dispersion

[2]   Ranjita Rout, Subhrajit Pradhan, Srikanta Patnaik "Role of DCF technique for enhancing optical fiber communication System utility" IRJET 2015

[3]   Mehtab Singh" Different Dispersion Compensation Techniques in Fiber Optic Communication System : A Survey" IJARECE 2015

[4]   Rupinder Kaur, Mandeep Singh "Analysis on Dispersion Compensation with DCF based on Optisystem-A Review" IJOES 2016.

[5]   Rekha, Mritunjay Kumar Rai "Analysis and Comparison of Dispersion Compensation by DCF Schemes & Fiber Bragg Grating"IJCTA 2016

[6]   Manpreet Kaur, Himali Sarangal, Praveen Bagga "Dispersion Compensation with Dispersion Compensating Fibers (DCF)" IJARCCE 2015.

[7]   Manpreet Kaur, Himali Sarangal "Analysis on Dispersion Compensation with Dispersion Compensation Fiber (DCF)" SSRG-IJECE-2015

[8]   Rupinder Kaur, Mandeep Singh "Dispersion Compensation in Optical Fiber Communication System Using WDM with DCF and FBG" IOSR-JECE-2016

[9]   N.Ravi Teja, M.Aneesh Babu, T.R.S.Prasad, T.Ravi" Different Types of Dispersions in an Optical Fiber"IJSRP-2012

[10]   Mr.Gaurang.H.Patel, Prof. Rohit.B. Patel, Prof.Sweta.J.Patel." Dispersion Compensation In 40 Gb/S Wdm Network Using Dispersion Compensating Fiber"Jikrece- Nov 12 To Oct 13

[11]   Ranjita Rout & Subhrajit Pradhan & Srikanta Patnaik "Role of DCF technique for enhancing optical fiber communication System utility" IRJET 2015.

[12]   Mehtab Singh" Performance Analysis Of Different Dispersion Compensation Schemes In A 2.5 Gbps   Optical Fiber Communication Link"IJTEEE2015

[13]   Kamal deep Kaur, Beant Kaur "Dispersion Compensation Techniques: A Review" Second International Conference On Innovative Trends in Electronics Engineering (ICITEE2)

[14]   www.optiwave.com

[15]   www.newport.com/t/fiber-optic-basics

[16]   Neha Verma, Deepak Bansal"Dispersion compensation and power optimization using multi stage SOA in conjunction with DCF & FBG"IJARCS 2017.

[17]   Deniz Gurkan "Summary Dispersion Compensation Techniques" Spring '99 – EE558 Project

[18]   Cohen, Leonard G., "Comparison of single mode fiber dispersion measurement" Journal of Lightwave Technology, 1985, LT-3 (5), pp. 958-966