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DESIGN AND PERFORMANCE IMPROVEMENT OF OPTICAL TRANSRECEIVER SYSTEM

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Abstract− *while optical networking had its origin in the research community a quarter of a centuary ago,the realisation of the vision has not had a straight trajectory.The main focus of this paper was first to design a general bidirectional Trans-receiver system using fiber. After validating the design, the dependence of various performance evaluating parameters onto various system parameters was evaluated .The dependencies/effect of various noise sources was also evaluated for validated design. After that, some techniques were proposed that if incorporated in our predesigned setup would improve the performance evaluating parameters and also their dependencies on the various system parameters.*

Keywords-*Networking, Bidirectional ,Transreciever, Fiber, Design*

I. INTRODUCTION

The use of light to send messages is not new. The idea of using glass fiber to carry an optical communications signal originated with Alexander Graham Bell. However this idea had to wait some 80 years for better glasses and low-cost electronics for it to become useful in practical situations. More and more interest has been recently devoted to the development of optical fiber communication systems. Fiber optic communication is a method of transmitting information from one place to another by sending pulses of light through optical fiber[1] .The light forms an electromagnetic carrier wave that is modulated to carry information .The potential bandwidth of optical communication systems is the driving force behind the worldwide development and deployment of light wave system.It is important to mention that optical fiber technology can be used at various wavelengths and some factors affecting the performance of fiber include material composition, geometry, light-source technology and physical environment. [2] Like other communication systems, optical communication system also faces problems like dispersion, attenuation and non linear effects that lead to deterioration in its performance[3]In this paper, particular attention has been put to reduce the effect of dispersion .So for this reason, various techniques have been proposed and it is important to work out an effective dispersion compensation techniques that lead to performance enhancement of optical system[4]. After designing a general bidirectional transreceiver system using fiber in optisystem software and validating it, the dependence of various performance evaluating parameters onto various system parameters was evaluated. After that , some techniques were proposed that if incorporated in our predesigned setup would improve the performance evaluating parameters and also their dependencies on the various system parameters.The techniques incorporated enhanced the performance of system to very great extent.

II. METHODOLOGY

The performance improvement techniques used in this paper are Dispersion compensation techniques using Optisystem software. OptiSystem is an optical communication system simulation package for the design, testing, and optimization of virtually any type of optical link in the physical layer of a broad spectrum of optical networks, from analog video broadcasting systems to intercontinental backbones. A system level simulator based on the realistic modeling of fiber-optic communication systems, OptiSystem possesses a powerful simulation environment and a truly hierarchical definition of components and systems. Its capabilities can be easily expanded with the addition of user components and seamless interfaces to a range of widely used tools. OptiSystem is compatible with Optiwave's OptiAmplifier and OptiBPM design tools[5].In order to remove the spreading of the optical or light pulses, the dispersion compensation is the most important feature required in optical fiber communication system. The most commonly employed techniques for dispersion compensation are as follows:

A. Dispersion Compensating Fibers (DCF)

DCF is a loop of fiber having negative dispersion equal to the dispersion of the transmitting fiber. It can be inserted at either beginning (pre-compensation techniques) or end (post-compensation techniques) between two optical amplifier's. But it gives large footprint and insertion losses [6-8]. The effect of fiber-optic dispersion of optical transmission Loss and dispersion are the major factor that affect fiber-optical communication being the high capacity develops. The EDFA is the gigantic change happened in the fiber-optical communication system; the loss is no longer the major factor to restrict the fiber-optical transmission. Since EDFA works in 1550 nm wave band, the average Single Mode Fiber (SMF) dispersion value in that wave band is very big, about 15-20ps /m(nm. km-1). It is easy to see that the dispersion become the major factors that restrict long distance fiber-optical transfers . Dispersion is defined as because of the different frequency or mode of light pulse in fiber transmits at different rates, so that these frequency components or models receive the fiber terminals at different time. It can cause intolerable amounts of distortions that ultimately lead to errors. In single-mode fiber performance is primarily limited by chromatic dispersion which occurs because the index of the glass varies slightly depending on the wavelength of the light, And light from real optical transmitters necessarily has non zero spectral width (due to modulation).

B. DCF dispersion compensation technology

In order to improve overall system performance and reduce as much as possible the transmission performance influenced by the dispersion, several dispersion compensation technologies were proposed . Amongst the various techniques proposed in the literature, the ones that appear to hold immediate promise for dispersion compensation and management could be broadly classified as: dispersion compensating fibers (DCF), chirped fiber Bragg gratings (FBG), and high-order mode (HOM) fiber. The idea of using dispersion compensation fiber for dispersion compensation was proposed as early as in 1980 but, until after the invention of optical amplifiers, DCF began to be widespread attention and study. As products of DCF are more mature, stable, not easily affected by temperature, wide bandwidth, DCF has become a most useful method of dispersion compensation.

C. Dispersion compensation scheme employed

The use of dispersion compensating fiber is an efficient way to upgrade installed links made of standard single mode fiber Conventional dispersion compensating fibers have a high negative dispersion -70 to -9ps/nm.km and can be used to compensate the positive dispersion of transmission fiber in C band. Of particular interests are the pre-, post- and symmetrical compensation techniques where each link is made of spans where the DCF is located before, after the SMF or symmetrically across the SMF. A DCF module should have low insertion loss, low polarization mode dispersion and low optical nonlinearity. By placing one DCF with negative dispersion after a SMF with positive dispersion, the net dispersion will be zero $D_{SMF} \times L_{SMF} = -D_{DCF} \times L_{DCF}$ Where D and L are the dispersion and length of each fiber segment respectively. Fiber based Compensation is done by three methods depending on the position of the DCF :

a. Pre-Compensation: The optical communication system is pre compensated by the dispersion compensating fiber of negative dispersion against the standard fiber .

b. Post-Compensation : The optical communication system is post compensated by the dispersion compensating fiber of negative dispersion against the standard fiber.

c. Symmetric compensation : In this Compensation scheme, the dispersion compensating fiber of negative dispersion is placed before and after the standard fiber to compensate positive dispersion of the standard fiber. The transmission link span at 40 GB/s is designed suitably by considering the fiber parameters of DCF and SMF so that the dispersion is compensated exactly. The gain of the erbium doped fiber amplifier (EDFA) placed after each fiber is such that is compensates the losses of the preceding fiber. The noise figure of the amplifiers is constant and set to 4 dB The signal is then launched over N spans of standard single mode fiber (SMF) of 60 km each two DCF fibers of 6 km are used before and after of the two SMF fibers of 30 km length each. Here four in-line-EDFA have been used in the link. In the receiver the signal is demultiplexed, detected by PIN detector, passed through the filter. The filtered electrical signal connected directly to the BER analyser which is used as a visualize to generate graphs and results such as eye diagram, BER, Q value, eye opening etc.

D. Fiber Bragg Grating (FBG) :Optical Fiber Bragg Grating (FBG) has recently found a practical application in compensation of dispersion-broadening in long-haul communication. In this, Chirped Fiber Grating (CFG) is preferred. CFG is a small all- fiber passive device with low insertion loss that is compatible with the transmission system and CFG's dispersion can be easily adjusted. CFG should be located in-line for optimum results. This is a preferred technique because of its advantages including small footprint, low insertion loss, dispersion slope compensation and negligible non-linear effects.

III. SETUP DESCRIPTIONS

For analysing various compensation techniques, various models were designed using opti system .Among those models , two setup's have been described below:

A .GENERAL TRANSMITTER -RECEIVER OPTICAL FIBER LINK:

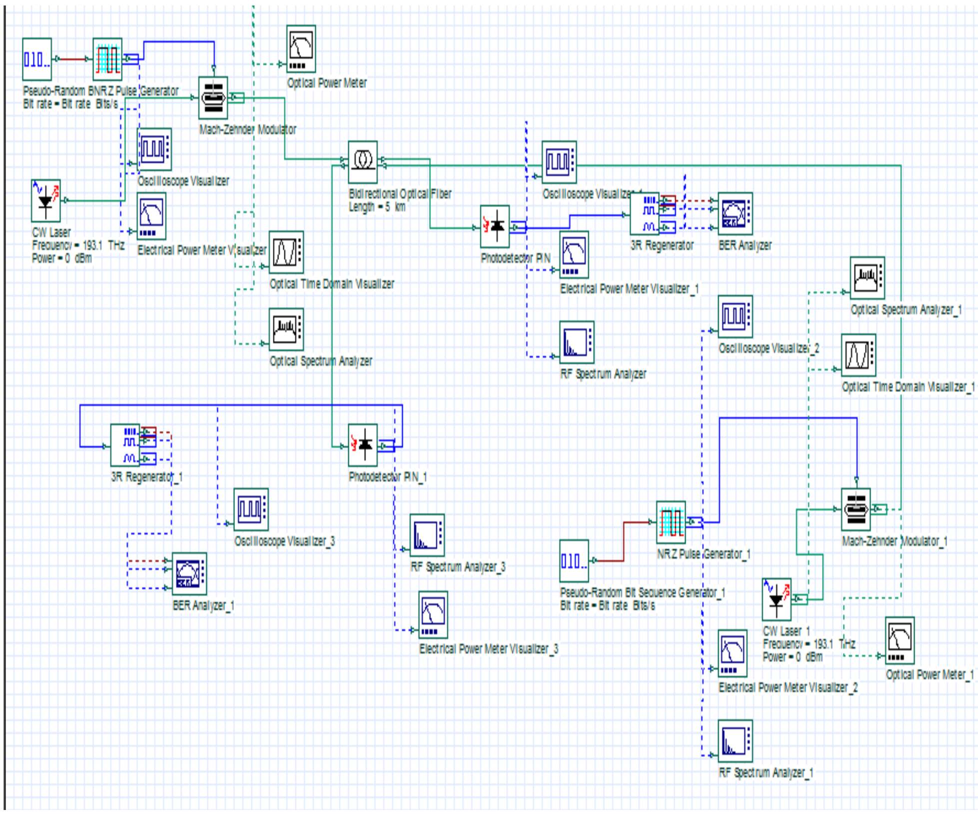

Figure 1 .General bidirectional transmitter receiver link

Figure shows general bidirectional optical fibre link. In this bidirectional optical transmitter link one side acts as transmitter and other acts as receiver and vice-versa i.e. data is transmitted in both the directions simultaneously. In this optical transmitter receiver link the data to be transmitted is produced by pseudo-random generator that is converted into digital signal using NRZ Generator. The optical carrier wave that is used to modulate digital signal is produced by continuous wave laser. The optical carrier wave and the signal to be transmitted is given to Mach Modulator that produces the modulated optical signal. The Mach-Zehnder modulator is an intensity modulator based on an interferometric principle. It consists of two 3 dB couplers which are connected by two waveguides of equal length. By means of an electro-optic effect, an externally applied voltage can be used to vary the refractive indices in the waveguide branches. The different paths can lead to constructive and destructive interference at the output, depending on the applied voltage. Then the output intensity can be modulated according to the voltage. The signal is allowed to travel through an optical fiber. After the signal has travelled the desired distance the modulated signal is allowed to pass through the photodetector pin that extracts the original signal from modulated signal. A PIN diode is a diode with a wide, undoped intrinsic semiconductor region between a p-type semiconductor and an n-type semiconductor region. The p-type and n-type regions are typically heavily doped because they are used for ohmic contacts. The wide intrinsic region is in contrast to an ordinary PN diode. The wide intrinsic region makes the PIN diode an inferior rectifier (one typical function of a diode), but it makes the PIN diode suitable for attenuators, fast switches, photodetectors, and high voltage power electronics applications. The original signal and the optical carrier signal is displayed with the help of oscilloscope visualizer and optical time analyzer respectively. The same process is repeated on the other side simultaneously.

B. Cascaded plus WDM dispersion compensation setup:

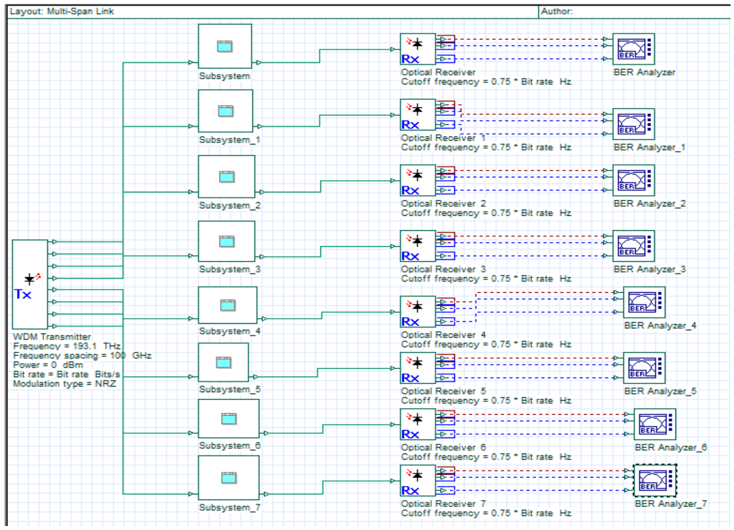

Figure 2.Cascaded plus WDM dispersion compensation setup

Description:

In the above setup is shown the WDM dispersion compensation technique and the cascaded dispersion compensation technique is performed together. The internal setup of the subsystem show below. The generating section consists of Gaussian pulse generator, bit sequence generator and optical visualizers. Bit sequence generator generates the input clock pulse that activates the Gaussian pulse generator. The modulation technique here employed is NRZ. The output of the bit sequence generator is fed to the Gaussian pulse generator that generates optical beam of optimum spectral with and high directivity. The Gaussian pulse generator is set at a frequency of 193.1 THz and power of 1dbm.the optical beam generated by Gaussian pulse generator is fed to the EDFA to compensate the dispersion. The OTD visualizers give the graphs/spectrum of time vs. optical power. The optical spectrum analyzer displays the optical spectrum. Now the output of the EDFA is fed to the Gaussian optical fiber which further increases the dispersion. The Gaussian pulse generator operates at a frequency of 193.1 THz having band width of 30 GHz. After this, the dispersed beam is fed to the successive sub systems (which consist of SMF, DCF, EDFA and optical fiber). After sufficient readings we came to the conclusion that the overall dispersion in this technique is reduced to greater extent.

In the above figure each subsystem consists of the following setup:

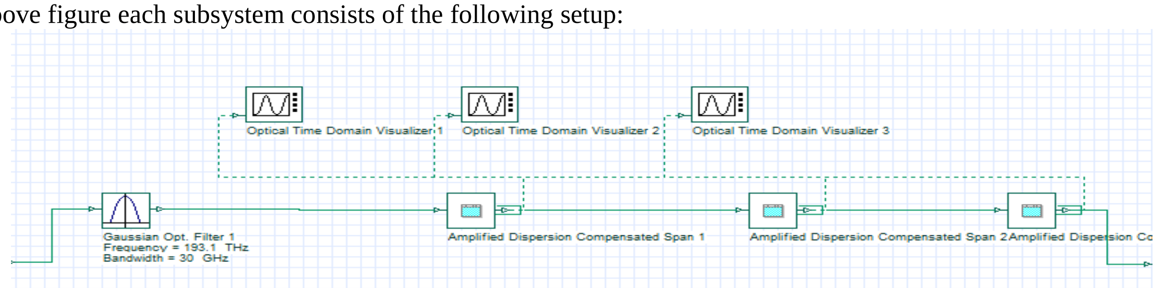

Figure 3.Internal setup of each subsystem

In the above figure each amplified dispersion compensated span setup consists of a setup of single SMF, DCF, EDFA and a Gaussian optical filter. The setup is shown in the following figure

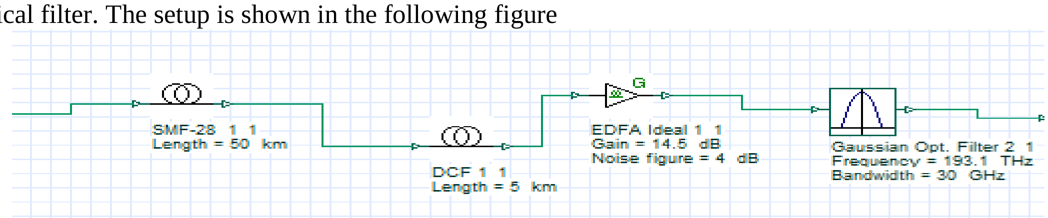

Figure 4.Internal setup of each amplified dispersion compensated setup

IV. RESULTS AND DISCUSSIONS

Based on data retrieved from multiple simulations on various design setups, various graphs were plotted that related various performances evaluating parameters with various system parameters and also derive performance comparison between various design setups.

Graph A: BER Vs fibre length for uncompensated setup

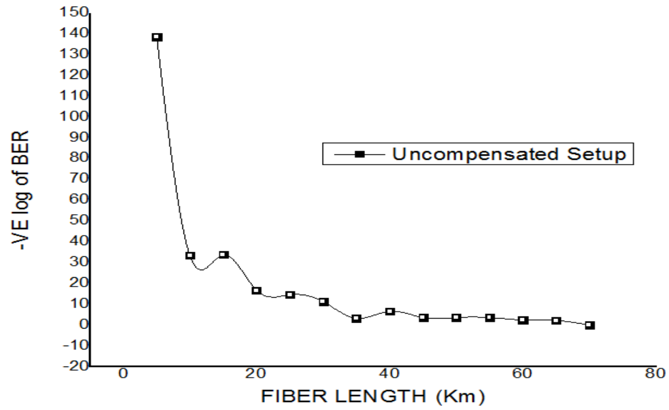

Figure 5. BER Vs fiber length for uncompensated setup

- From the evaluated graph it was seen that BER increases with increase in fibre length.
- The maximum fibre length within which performances satisfactory found to be under 20-40km.
- The minimum BER in case was obtained at around fibre length of 5km (opposite of order of 10^{-140}).

Graph B: BER Vs fiber length for various compensation techniques

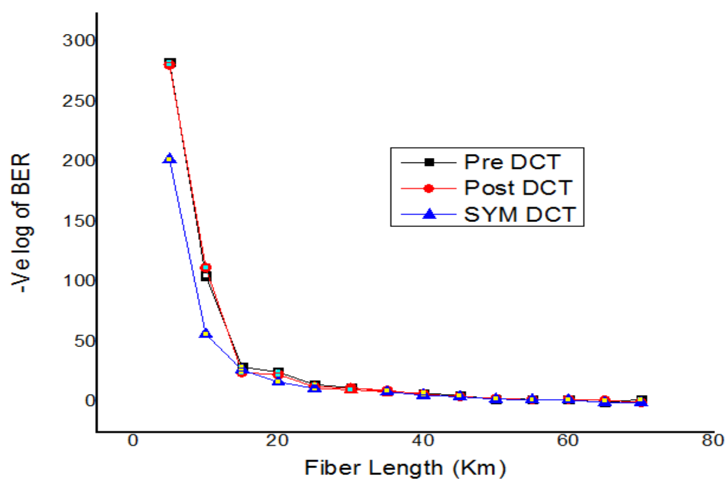

Figure 6. BER Vs fibre length for various compensation techniques

BER values as recorded for various DCT's namely pre DCT, post DCT and symmetrical DCT's were plotted mutually against variable fibre length .The inferences from the graph are as follows:

- The BER values for all the setup's showed as gradual increase with increase in fiber length
- Out of the 3 compensation techniques, pre DCT yielded best BER values.
- The maximum fibre length upto which performance remains satisfactory increased to 40km to 60km.
- The best BER values were obtained around a fiber length of 10km and were of the order of 270(10^{-270}).

Graph C: Dispersion Vs fiber length for uncompensated setup

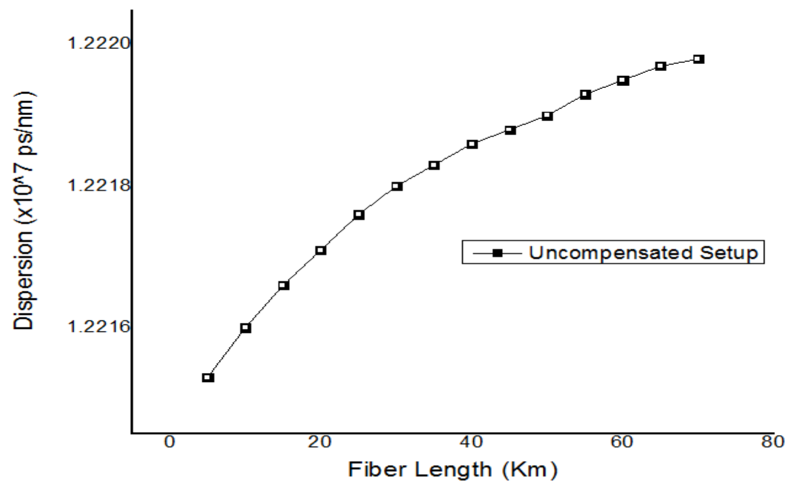

Figure 7. Dispersion Vs fiber length for uncompensated setup

Here dispersion variation with increase in fiber length was recorded and plotted .The inferences from the graph are as follows:

- A dispersion showed a linear rise with increase in fiber length.
- For the same fiber length the dispersion values for uncompensated setup were extremely large compared to dispersion compensated setups.

GRAPH D: Dispersion vs. fiber length for various compensation techniques

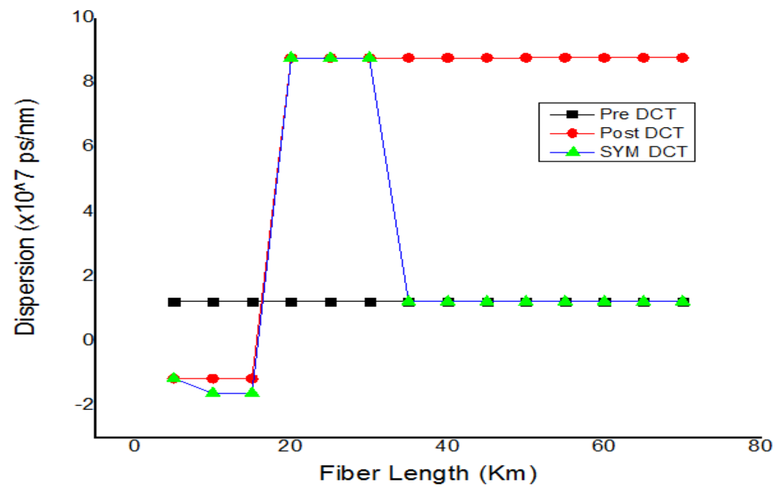

Figure 8. Dispersion vs. fiber length for various compensation techniques

Here the o/p dispersion as recorded for various setups was plotted against variable fiber length .The inferences from the graph are as follows:

- Out of the three compensation techniques, symmetrical DCT yielded the lowest values of dispersion while as pre DCT showed almost flat dispersion response.

Dispersion values showed a gradual increase with increase in fiber length

Graph E: Dispersion Vs fiber length for FBG setup

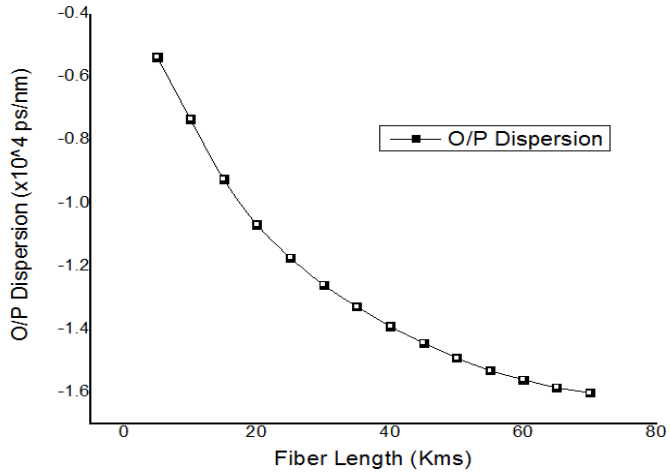

Figure 9. Dispersion Vs fiber length for FBG setup

In this setup, the dispersion in the system was compensated by incorporating uniform FBG device. The dispersion generated in such a setup against variable fiber length was plotted. The inferences from the graph are as follows:

- The dispersion generated was improved from being positive and of order of 10^7 to being negative of 10^{-4}.
- The dispersion generated showed a linear decrease with increase in fiber length.
- The pulse becomes narrower thus it is more available with increase in fiber length.
- Thus such a setup supports pulse narrowing as a transmission length is increasing.

Graph F: Dispersion Vs fiber length for cascaded WDM

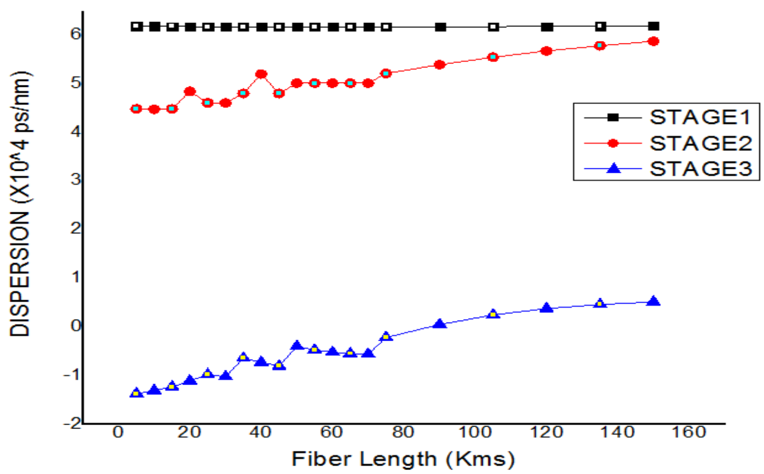

Figure 10. Dispersion Vs fiber length cascaded WDM

In this setup, stage wise dispersion was measured and plotted against variable fibre lengths. The inferences from graph are as follows:

- All the stages reduced the dispersion values from being positive and of order of 10^7 ps/nm to being negative and of the order of 10^4 ps/nm.

Dispersion was found upto be minimum for stage 3 followed by stage 2 and stage 1

Graph G: BER Vs fiber length for cascaded WDM

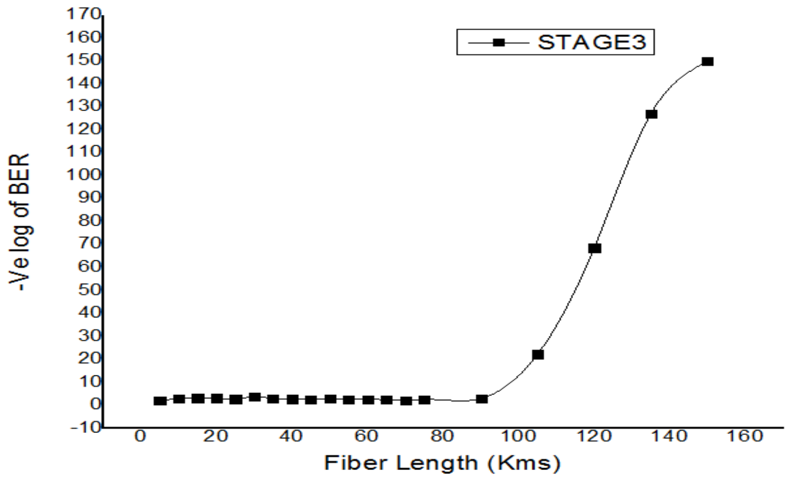

Figure 11. BER Vs fiber length for cascaded WDM

The BER values at output of third stage were measured and plotted against variable fiber length. The inferences from the graph are as follows:

- The maximum fiber length upto which the transmission remains satisfactory got increased from 40km in case if uncompensated setup to 160km.
- The BER values showed gradual decrease for higher fiber lengths.

V. CONCLUSION

Here various performance enhancement techniques were proposed. The proposed techniques yielded improved result for performance evaluating parameters compared to already published work. We concluded that a bi-directional transreciever optisystem were equipped with cascaded network of dispersion compensators and modulators multiplexed using WDM yielded the best performance evaluating parameters.

VI. REFERENCES

[1] “Understanding optical communications” by Harry J.R.Dutton.
[2] http://gautier.moreau.free.fr/cours_optique/chapter01.pdf.
[3] John M. Senior “*optical fiber and communications principles and practice, third edition*” England, 2009
[4] N.K Kahlon and G. Kour “*various dispersion compensation techniques*” deptt. Of ECE, Rayat and Bahara institute, India, 2014
[5] Optiwave community forum
[6] “G.K.S,Devra, “Different compensation techniques to compensate dispersion in fiber optics” ,International journal of engineering and information Technology,vol,3,no.1,pp,2011
[7] J.Toulouse , “optical nonlinearities in fibers; review, recent examples and system applications,”Light wave technology journel of,vol,23,no.11,pp.3625-3641,2005
[8] P .Nouchi, B.Dany,J.F.Campion,L.A,de Montmorillion,P.Sillard,and A.Bertainai, “Optical communication and fiber design ,”vol .14,no.58,pp.1586-1602,spring,2003

