Reducing BER for Long Haul 32 Channel WDM Network using Mix Dispersion Compensation Technique

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Abstract: **The purpose of this paper is to increase the length of optical fiber for long haul transmission WDM system, specifically a system employing a single-mode optical fiber for 32 channel using Dispersion Compensation Technique. There are three types of dispersion compensation technique first one is PRE Compensation Technique, Second one is POST Compensation Technique and Third one is MIX compensation Technique. In this paper investigated mix Compensation Technique. In this technique fiber placement follows the sequence of DCF, SMF, DCF EDFA amplifiers. WDM system complies to the following configuration scheme: RZ-modulation encoding at the transmitter side with bit rate of 10 Gbit/s and 32 channel with channel spacing 100 GHZ.). In the receiver side we are using avalanche photo diode (APD) because APDs offering a combination of high speed and high quantum efficiencies. In this thesis we have taken standard single mod optical fiber with dispersion of 16 ps/nm-km and dispersion compensation fiber with dispersion of -100 ps/nm-km to compensate the dispersion of optical fiber with fiber span of 10 Km. by using these parameters we can reduce the bit error rate and improve the Q-factor for 32 channel long haul transmission. In this work we are transmitting the signal up to 150 Km with minimum bit error rate and improved Q-factor.**

Keywords: **Wavelength division multiplexing (WDM); Dispersion compensating fiber dispersion (DCF); Single mode fiber (SMF); Bit error rate (BER).**

I. INTRODUCTION

Communication via optical fiber is a best method of transmitting information from one place to another in the form of light. In recent years, with the rapid growth internet business needs, people urgently need more capacity and network systems. So the demand for transmission capacity and bandwidth are becoming more and more challenging to the carriers and service suppliers. As the optical fiber transmission systems evolved to longer distances and higher bit rates, the linear effect of fibers, which is the attenuation and dispersion, becomes the important limiting factor. As for WDM (Wavelength Division Multiplexed) systems that transmit multiple wavelengths simultaneously even at higher bit rates and distances, the nonlinear effects in the fiber begin to present a serious limitation [1]. Under the situation, with its huge bandwidth and excellent transmission performance, optical fiber is becoming the most favorable delivering media and playing more and more important role in information industry. The optimal design and application of optical fiber are very important to the transmission quality of optical fiber transmission system. Therefore, it is very necessary to investigate the transmission characteristics of optical fiber. And the main goal of communication systems is to increase the transmission distance. Loss and dispersion are the major factor that affect fiber-optical communication being the high-capacity develops. Wavelength Division Multiplexed Passive Optical Network (WDM-PON) is an attractive solution to satisfy the worldwide growing demand for transmission capacity in the future next generation fiber optical access networks. The maximum reach of the Dense WDM-PON (DWDMPON) transmission system can be severely limited by chromatic dispersion (CD) [2], [3]. We have the different modulation techniques but we select RZ techniques because We quantify the polarization-mode dispersion (PMD)-induced system outage probability by means of numerical simulations for nonreturn-to-zero (NRZ) and return-to-zero (RZ) data formats with proper comparative conditions and find that RZ performs better than NRZ [4]. RZ modulation technique shows the optimum performance over the other technique. Here we are using bit rate of 10 Gbit/s. It is observed that at bit rate (10 Gb/s/channel) per channel multiplexed optical system shows much better performance matrices (Q, BER, eye pattern) [6].

II. DIFFERENT METHODS USED FOR REDUCING CHROMATIC DISPERSION

Dispersion Compensating Fiber (DCF) is a popular solution to compensate the dispersion after every span which is suitable for WDM systems. . DCF has higher CD coefficient than transmission fiber, and with opposite sign, in the order of -80 ps/nm/km to -100 ps/nm/km. This fiber is normally prepared according to the dispersion value of the standard transmission fiber length. Therefore, the DCF length required is around 4 (SSMF) to 20 (NZDSF) times shorter than the transmission fiber. Fig.(1) illustrates the idea behind the dispersion compensation technique, where the SMF is used followed by DCF. An Improved methodology for Dispersion

Compensation is discussed in this work, which offers much better performance compared to FBG compensation in long haul Optical Fiber Networks [7]. Compare three different dispersion compensation techniques, namely pre-, post, and symmetrical dispersion compensations by using DCFs.

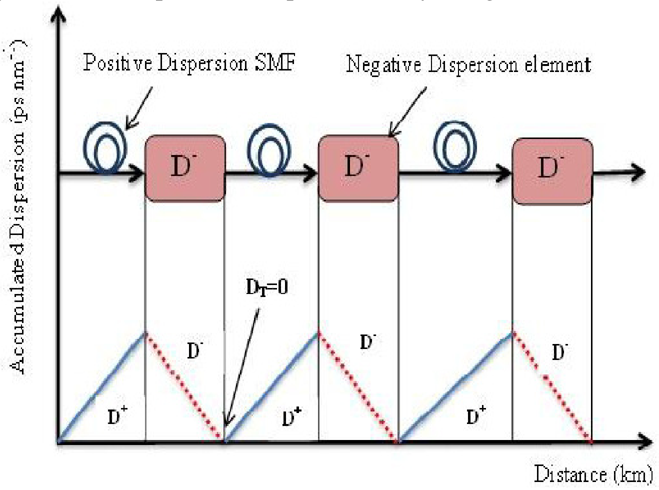

Figure 1: An illustration of DCF technique

These examples consider just one channel. The bit rates used for the examples are 2.5 Gb/s and 10 Gb/s, respectively. In our simulations we have used optical amplifiers after each fiber to compensate the fiber loss. Dispersion parameter of SMF is 16 ps/nm-km and it is 120 km long. Therefore, total accumulated dispersion is 16×120 = 1920 ps/nm. This much dispersion can be compensated by using a 10 km long DCF with – 80 to -100 ps/km-nm dispersion. In post-compensation case, DCF is placed after SMF whereas in pre-compensation case it is inserted before SMF. In symmetrical compensation case, fiber placement follows the sequence of DCF, SMF, SMF, DCF. Here we will use mix compensation technique for long haul transmission because mix compensation technique gives better performance and low BER for long distance transmission.

III. OPTICAL COMMUNICATION & LOSSES IN COMMUNICATION

Fiber optic communication is a method of transmitting information from one place to another by sending light through an optical fiber. The light forms an electromagnetic carrier wave that is modulated to carry information. The process of communicating using fiber optics involves the following basic steps: Creating the optical signal using a transmitter, relaying the signal along the fiber, ensuring that the signal does not become too distorted or weak, and receiving the optical signal and converting it into an electrical signal. When different wavelengths of light pulses are launched into an optical fiber, these pulses will traveled at different speeds due to the variation of refractive index with wavelength. These light waves tend to get spread out in time after traveling some distance in the optical fiber and this is continued throughout the length of the fiber. This phenomenon of boarding the pulse width is called dispersion. There are many more errors in optical fiber communication will arise due to the material of optical fiber, structural imperfection or due to the refractive index change.

IV. SIMULATION SET UP AND DESCRIPTION

In this paper OptSystem simulation software is used for this work which gives the environment almost the exact physical realization of a system. The simulation setup is shown in the Fig.2. The experimental setup with DCF for simulation scheme OptiSystem 7.0 software for the investigation of reach improvement for high speed 32 channel WDM-PON system using MIX DCF chromatic dispersion compensation methods is depicted in Fig 6.1 A performance of simulated scheme was evaluated by the obtained BER value of each WDM channel in the end of fiber optical link. The BER value recommended by ITU (International Telecommunication Union) for fiber optical transmission systems with data rate 10 Gbit/s per channel is defined to be no more than 10^{-9} [8] As one can see in Fig. 2, DWDM-PON simulation scheme consists of 32 channels. The frequency grid, anchored to 193.1 THz and channel spacing equal to 100 GHz frequency interval or 0.8 nm wavelength intervals is chosen. Each channel consists of data source, Nonreturn-to-zero (RZ) driver, continuous wavelength (CW) laser 1550 and external Mach-Zehnder modulator (MZM). Data source generates optical data stream with data rate equal to 10 Gbit/s. This data stream represents the information needed to transmit in fiber optical transmission system. Generated bit sequence from data source is sent to RZ driver where RZ pulses are formed. These RZ pulses are sent to MZM. Finally, the CW laser light beam is modulated via the MZM and optical pulses are formed. These optical pulses from all 32 channels are coupled by wavelength division multiplexer and sent into standard single mode fiber (dispersion 16 ps/nm-km) with EDFA amplifier. Simulated a thermal high-performance WDM multiplexers and demultiplexers are absolutely passive optical components with insertion loss up to 3dB each and channel spacing 100 GHz. We are simulating here for 150 km length of optical fiber with mix DCF compensation. Receiver section consists of receiver with optical filtering, Avalanche photodiode, Bessel electrical filter and BER analyzer to evaluate the quality of received optical data signal and also used for measure the value of Q factor. Optical filters are necessary to separate each WDM channel from common optical stream. After optical filtering each channel is converted to electrical signal using Avalanche photodiode and filtered by Bessel electrical filter to reduce noise of electrical signal.In this set up we are using RZ techniques because We quantify the polarization-mode dispersion (PMD)-induced system outage probability by means of numerical simulations for nonreturn-to-zero (NRZ) and return-to-zero (RZ) data formats with proper comparative conditions and find that RZ performs better than NRZ [3]
Here we are using mix compensation technique to compensate the chromatic dispersion. This technique increase the value of Q factor and reduce the BER we can observe these value by using BER analyzer.

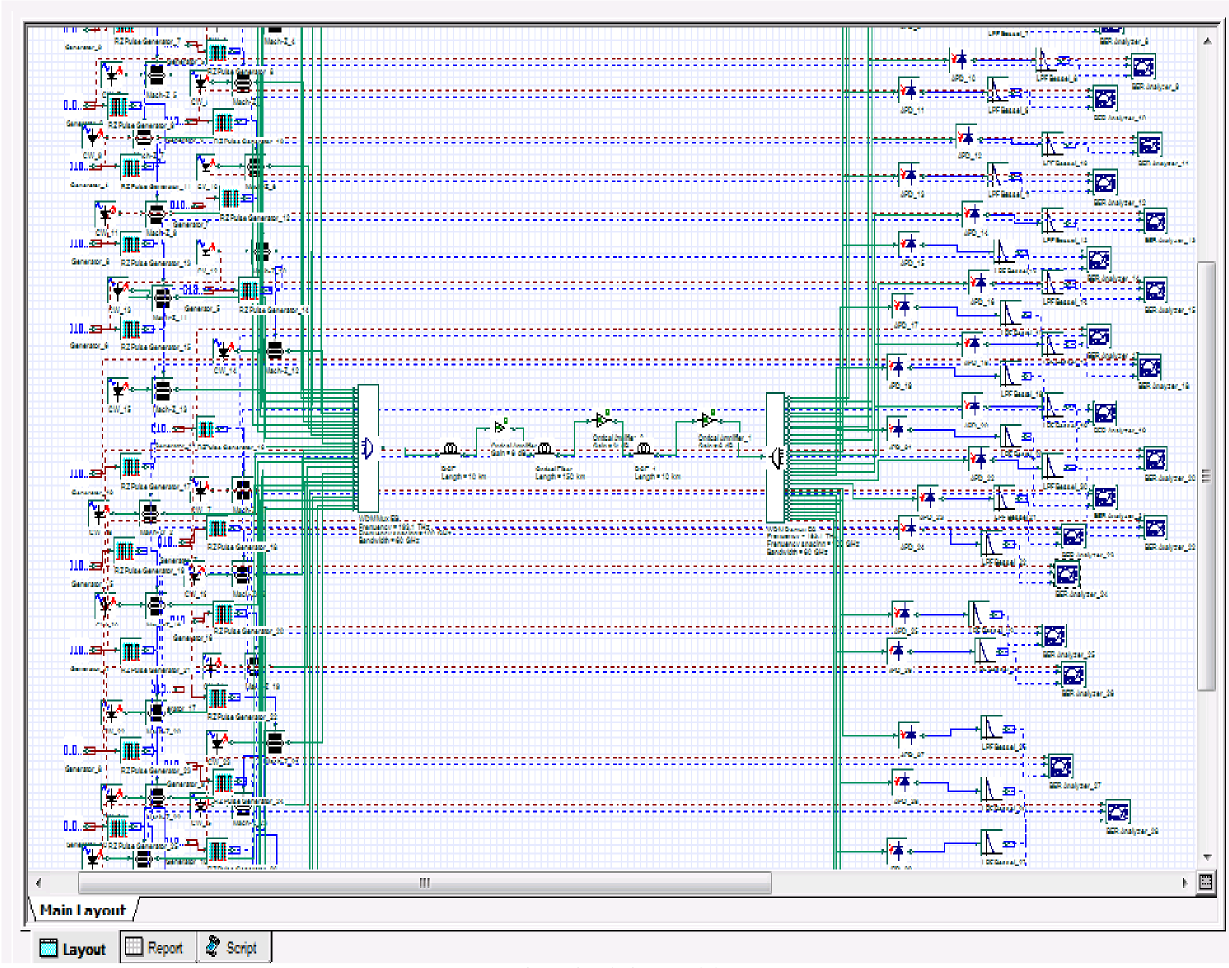

Fig.2 Simulation Model

V. RESULTS AND DISCUSION

Hee we are discussing about the simulation setup and results of Reduction of BER and improvement of Q factor Using MIX DCF. Firstly, the simulation parameters are shown as a scenario of Reduction BER. The analysis has been carried out with simulation studies under OptiSystem 7.0 environment using Dispersion Compensation technique.

Eye Eiagrams for nrz and rz modulation format

Figures of eye diagram for worst channel and best channel shown in fig(3-4), the worst channel means the channel performance is very poor i.e. minimum Q factor and highest BER and the best channel is the channel which performances is better i.e. minimum BER and maximum Q factor. Our simulation for 32 channels with RZ modulation encoding with MIX DCF compensation technique. in our work 32 channel can transmit up to 150 km with minimum BER. In this case the worst channel 1 with BER $3.65397*10^{-13}$, Q factor is 7.12 and the best channel is channel 32 with BER $1\text{-}02423*10^{-27}$, Q factor is 10.81.

The BER value recommended by ITU (International Telecommunication Union) for fiber optical transmission systems with data rate 10 Gbit/s per channel is defined to be no more than 10^{-9} [8].

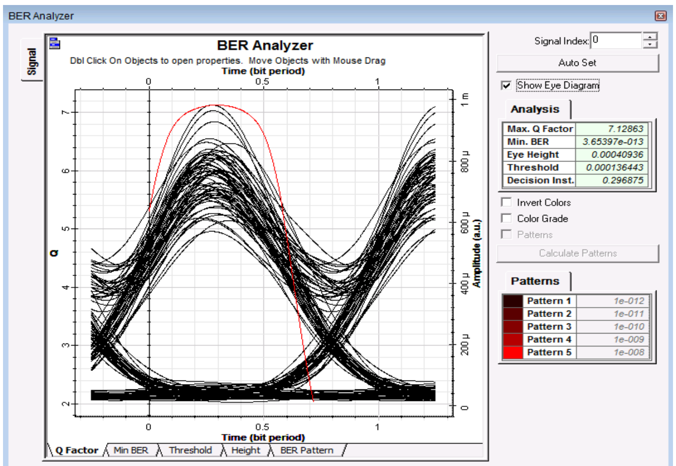

Fig. 3 Eye Diagram for worst channel RZ modulation

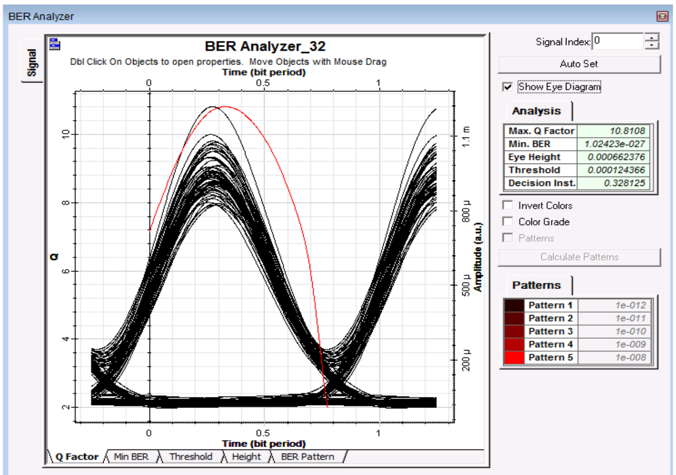

Fig. 4 Eye Diagram for best channel RZ modulation

The above result shows that when we go for the long distance communication with the RZ and NRZ modulation formats then RZ modulation formats performs well then that of the NRZ modulation. NRZ modulation format is severely affected by the dispersion and the Q factor of the system becomes very low which is not suited for long distance data transmission but the RZ modulation format performs better for long distance transmission.

VI. ANALYSIS AND FUTURE WORK

This dissertation is mainly concerned on investigating the different types of the modulation format and dispersion compensation technique which is being used in optical long haul communication networks. We have been discussed different types of modulation format in which RZ provides most efficient system design. Although we have discussed the long haul system performance with the help of Pre and MIX compensation technique. It is quite clear from the simulated result that the RZ modulation format is performing well for long haul transmission and has the value of Q factor of 10.81 which is good enough for transmitting the digital signal and NRZ modulation format gives the value of Q factor 7.1 which is not good as compared to RZ modulation format. We also analyzed that MIX DCF compensation technique gives better performance as compared to PRE DCF compensation technique. We have been discussed different types of modulation format in which RZ provides most efficient system design. Although we have discussed the long haul system performance with the help of Pre and MIX compensation technique. In our investigation we used DCF for dispersion compensation but we can also use FBG (fiber brag grating). In future with the help of RZ modulation encoding and MIX dispersion compensation technique with using FBG we can transmit the signal up to great extent and with the help of WDM, RZ modulation and MIX FBG compensation we can also increase the number of channels such as 64 and even more channels and distance travelled by the signal. By using WDM technique we are now able to send multiple signal and the problem of dispersion is resolved by using DCF and FBG.

VII. CONCLUSION

All above articles Proposed that the method for reducing bit error rate and Improve Long Haul transmission for 32 Channel. The BER value recommended by ITU (International Telecommunication Union) for fiber optical transmission systems with data rate 10 Gbit/s per channel is defined to be no more than 10^{-9}. In this Work BER 1-02423*10^{-27}, Q factor 10.81 is obtain by using mix Compensation Technique. Bit Error Rate can be improved by using Mix Compensation Technique by DCF.

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