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EFFECT OF TOD AND GVD IN LONG-HAUL OFC SYSTEM

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Abstract— **As we know Optical communication Network offers very high potential bandwidth and flexibility. In terms of high bit-rate transmission. However, their performance slows down due to some parameter like dispersion, attenuation, scattering. In long haul application, dispersion is the main parameter which needs to be compensated in order to provide better service. Fiber Braggs Grating (FBG) is one of the most widely used element to compensate it, however its performance slows down with the increase in distance.**

This paper presents an investigation on Pulse distortions due to the third-order dispersion (TOD) on very high speed long distance single mode optical fiber communication system using OptiSystem. Presence of the TOD introduces broadening on the propagating pulse. The impact of TOD is observed at the receiving end of transmission line considering the variation of different factors such as transmission reach, bit rate, duty cycle.BER performance are also considered here.

Index Terms— **Third order dispersion (TOD)**, **Dispersion Compensation Fiber (DCF)**, **Bit-Error rate(BER), Standard single mode fiber(SSMF)**

I. Introduction

In last few years, with the rapid increasing internet service users, people urgently need more capacity and higher bandwidth. So the demand for transmission capacity and bandwidth are becoming more and more challenging to the service suppliers. Under this situation, with its large bandwidth and excellent transmission performance, optical fiber is becoming the most favorable transmission media. The optimum 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 and data carrying capacity. Attenuation and dispersion are the major factor that affect optical fiber communication being the high-capacity and bandwidth develops. The main objective of an optical fiber communication system is to transmit the maximum number of bits per second over the maximum possible distance with the fewest errors. In this communication system, dispersion is the major limiting factor as the bit rate and the transmission distance increases. Dispersion is the main parameter which needs to be compensated for faithful signal transmission and NZDSF and DCF is dispersion compensation techniques.

There have been several dispersion-managed (DM) techniques to compensate for the dispersion effects. Among the different dispersion compensation techniques, there are two methods that are very useful, one using the dispersion compensation fiber (DCF), optical fiber Bragg Grating (FBG) and and high-order mode (HOM) fiber. Fiber Bragg Grating is only for short distance communication. We used DCF for long distance optical fiber communication.

In present paper we have examined the effect of TOD and GVD on the pulse shape for ultra-high speed (40 GB/s and more) and also evaluate the performance of system under different duty cycle, bit-rates and different transmission models like SSMF and NZDCF fiber.

II. THE EFFECT OF DISPERTION ON OPTICAL FIBER TRANSMISSION

Attenuation loss and dispersion loss are the majored factors that affect optical fiber communication. The attenuation loss is no longer the major factor to restrict the fiber-optical transmission (at 1550 nm optical fiber cable attenuation is minimum). The EDFA is the highly suitable amplifier for optical fiber communication system in C band (1530nm-1560nm). Since EDFA works in 1550 nm wave band, the average Single Mode Fiber (SMF) dispersion value in that wave band is high. It is easy to see that the dispersion become the major factors that restrict long distance optical fiber communication. 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 goes 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). Dispersion increases bandwidth requirement of optical fiber due to pulse broadening.

III. DISPRSION COMPENSATION SCHEME EMPLOYED

The use of dispersion compensating fiber is an efficient way to upgrade installed links made up of standard single mode fiber. There is positive second-order and third-order dispersion value in SMF (single mode fiber), while the

DCF dispersion value is negative. So by inserting a DCF, the average dispersion is close to zero. Conventional dispersion compensating fibers have a high negative dispersion -70 to -90 ps/nm.km and can be used to compensate the positive dispersion of transmission fiber in C band. 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.

There will be problem in compensation of fiber when bit rate increases above 100Gb/s , short optical pulse of width 1ps is used for each bit slot. For such short optical pulses, the pulse spectrum becomes broad enough that it is difficult to compensate GVD over the entire bandwidth of the pulse. So there is one simple way of Dispersion Compensation in such a way that both $\beta 2$ and $\beta 3$ are compensated simultaneously. For a fiber link containing two different fibers of lengths $L1$ and $L2$, the conditions for broadband dispersion compensation are given

$\beta_{21}L_1+\beta_{22}L_2=0$ and $\beta_{31}L_1+\beta_{32}L_2=0$

where β_{2j} and β_{3j} are the GVD and TOD parameters for fiber of length L_j (j =1,2).

IV. SYSTEM SET UP AND SIMULATION DETAILS

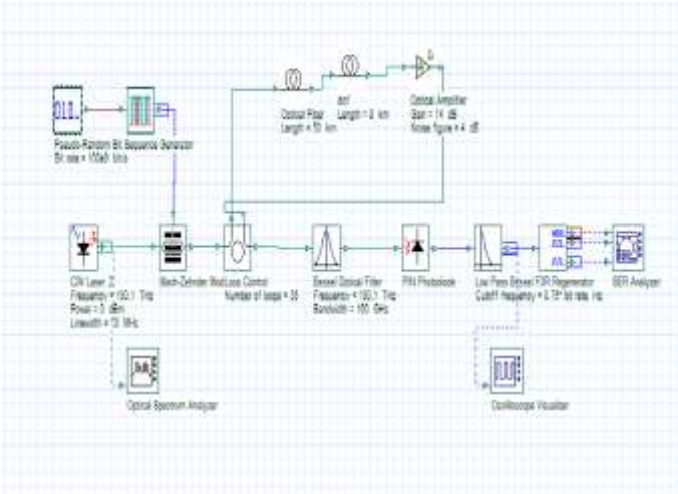


fig.1 ssmf-dcf

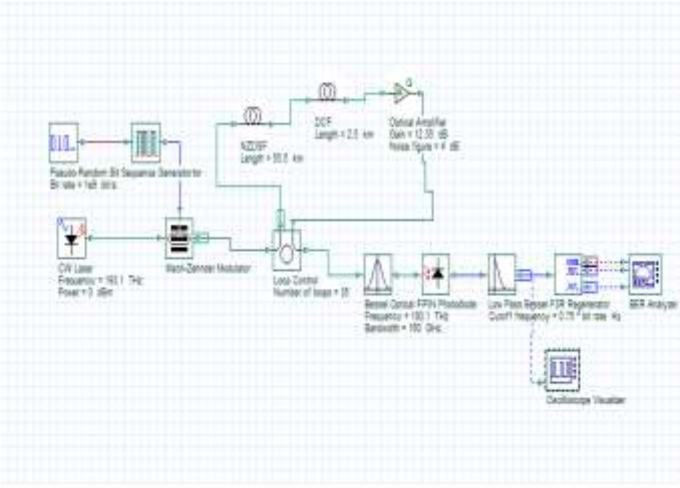


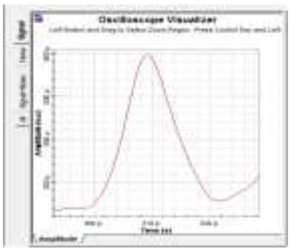
Fig.2 nzdsf-dcf

In this paper we used two models one is ssmf-dcf (standard single mode dispersion compensation fiber) and another one is nzdsf-dcf (non zero dispersion shifted fiber dispersion compensation fiber). In the transmitter section we used laser source (CW laser), PRBS generator and MZ modulator. We use Pseudo-random bit sequence which has bit rate vary from 1gbps to 160gbps.The output of PRBS is given to RZ modulator(which is more superior than NRZ) driver which produces GAUSSIAN format pulse with duty cycle of 0.5(variable). The output of laser source is CW type and has peak power of 1mW. The line width was set to 10 MHz full width half maximum. The modulator is of Mach-Zehnder modulators have the Excitation ratio 30db. A Mach-Zehnder modulator is a intensity modulating signal light, using a simple drive circuit for the modulating voltage. The loop control system has variable loop .Each span consists of 58km (50 km SSMF and 8 km DCF) in first model.

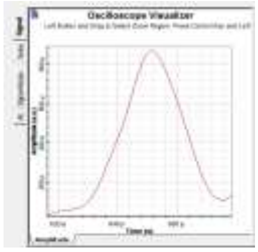
The SMF have the reference wavelength of 1550nm with attenuation 0.21dB/km and Dispersion 16ps/nm km. The parameters for DCF are attenuation 0.5db/km and dispersion - 100 ps/nm km. In another model, signals are transmitted through NZDSF of the length of 55.5 km and Then the signals are transmitted through a DCF fiber of the length of 2.5 km(one span length58 km). The EDFA is select in gain control mode with gain of 14 dB for SSMF-DCF model and 12.35 dB for NZDSF-DCF model. The optical Bessel filter with 3dB bandwidth equal to 160 GHz (it depend on maximum data rate transfer). At the receiver side, the optical signal is transformed in to an electrical signal by a PIN photodiode The PIN photo detector have the Responsivity1A/W and Dark current 10nA. The electrical signal is filtered by a low pass Bessel filter with Cut off frequency “0.75*Bit rate” Hz. For this low pass Bessel filter we set fourth order. Here we used different dispersion slope for ssmf-dcf and nzdsf-dcf model.

V. RESULTS

SSMF-DCF | NZDSF -DCF



Fig(40gbps)



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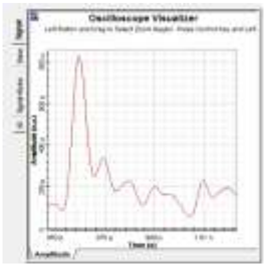
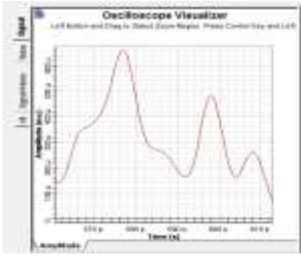
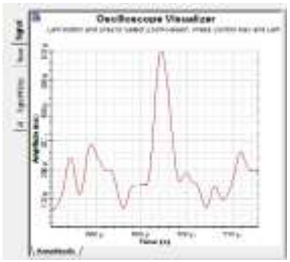


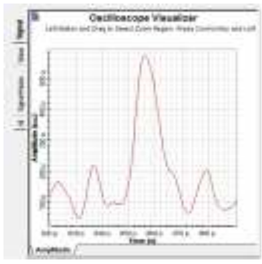
Fig(100gbps)



Fig(100gbps)



Fig(160gbps)



Fig(160gbps)

Here in the first simulation TOD effect is observed for the Gaussian pulses propagating through SSMF-DCF and NZDSF-DCF system by varying bit rates only. Incident power is 1 mW and duty cycle is 50%. Bit rate is varied from 40 Gb/s to 160 Gb/s. In case of 100 Gb/s, for Gaussian pulse after transmission of 2030 km and exhibits a long oscillatory tail extending around 40 ps for SSMF-DCF and 20 ps for NZDSF-DCF. For 160 Gb/s, for Gaussian pulse an oscillatory tail is found on both edges of pulse which extends around 80 ps for SSMF-DCF and 40 ps for NZDSF-DCF. So the NZDSF has small oscillatory tail than SSMF and minimum dispersion.

For Duty cycle 0.5 as we increases the distance from 580Km to 2030Km in SSMF-DCF Quality factor decreases from 2.66844 to 1.80001 and in NZDSF-DCF Quality factor decreases from 2.86835 to 1.15322. So the decrease in

Quality factor due to distance performance of system decreases and Losses are increasing. So as increase in distance bit error rate increases that's mean system performance decreases.

In SSMF-DCF as we increases the duty cycle from 0.1 to 0.5 Quality factor increases from 2.06911 to 2.46301 and further increase in the duty cycle from 0.5 to 0.9 Quality factor decreases from 2.46301 to 2.27781.Q-factor is maximum at duty cycle 0.5.In NZDSF-DCF as we increases the duty cycle from 0.1 to 0.9 Quality factor increases from1.81508 to 2.39484. So the increase in Quality factor due to duty cycle performance of system increases and Losses are reducing.

VI. CONCLUSION

In this present paper, the TOD effect has been calculated by varying bit rate, transmission distance, duty cycle, and different transmission models for DM system. The presence of the TOD causes pulse broadening long oscillatory tail. When bit rate is 40 Gb/s oscillatory tail occurs but it should be negligible. When bit rate increases to 100 Gb/s or more, long oscillatory tail is increasing and TOD effect observed. The outcome of this paper will be useful for designing and implementing very high speed long distance optical fiber communication system.

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