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EFFECTS OF POLARIZATION MODE DISPERSION INOPTICAL COMMUNICATION SYSTEM

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Abstract : The effects of Polarization Mode Dispersion (PMD) cause signal distortion. When we increase the bit rates, PMD has been found to be a time varying and an unstable phenomenon. Thus compensation of PMD is required since it distorts the signal and broadens the pulse in a statistical manner. We analyze the PMD effects and simulations have been done using the OPTISYSTEM. Fiber bragg compensator has been suggested to overcome the dispersion limit. According to the relative position of the Dispersion Compensating Fiber (DCF) and Single Mode Fiber (SMF), Post- Compensation, Pre-Compensation and Mixed Compensation techniques have been proposed. Different location on the system will generate different nonlinear effects. Three different dispersion compensation techniques have been discussed and results have been analyzed.

Keywords : Birefringence, Differential group Delay, Polarization Mode Dispersion.

1. INTRODUCTION

Polarization mode dispersion(**PMD**) is a form of modal dispersion where two Different polarizations of light in a waveguide, which normally travel at the same speed, travel at different speeds due to random imperfections and asymmetries, causing random spreading of optical pulses. Unless it is compensated, which is difficult, this ultimately limits the rate at which data can be transmitted over a fiber. It's a source of pulse broadening which results from fiber birefringence and it can become a limiting factor for optical fiber communications at higher transmission rates[1]. It is random effect due to both intrinsic (caused by non- circular fiber core residual and geometry and residual stresses in the glass material near the core region) and extrinsic (caused by stress from mechanical loading, bending or twisting of fiber) factors which in actual manufactured fibers result in group velocity variation with polarization state.

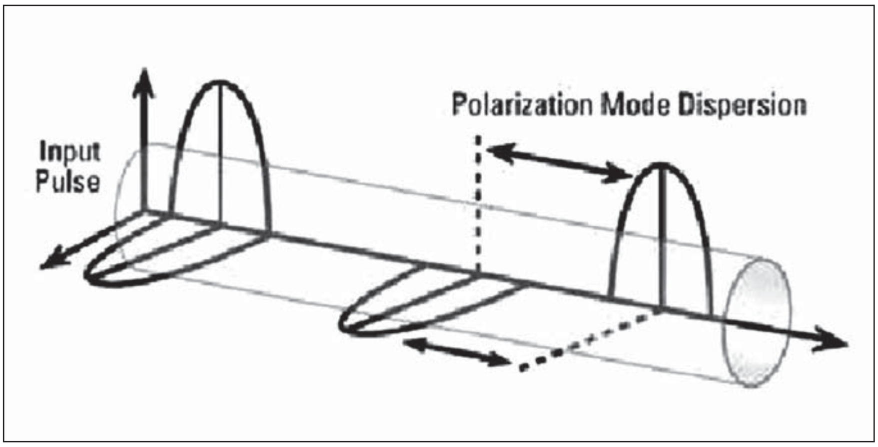

Figure 1. Time domain effect of Polarization Mode Dispersion (PMD)

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PMD in a short fiber length with a pulse being launched with equal power on the two birefringent axes, becoming two pulses at the output separated by the differential group delay[2-3].

In an ideal optical fiber, the core has a perfectly circular cross-section. In this case, the fundamental mode has two orthogonal polarizations(orientations of the electric field) that travel at the same speed. The signal that is transmitted over the fiber is randomly polarized, i.e. a random superposition of these two polarizations, but that would not matter in an ideal fiber because the two polarizations would propagate identically. In a realistic fiber, however, there are random imperfections that break the circular symmetry, causing the two polarizations to propagate with different speeds[4-7]. In this case, the two polarization components of a signal will slowly separate, e.g. causing pulses to spread and overlap. Because the imperfections are random, the pulse spreading effects correspond to a random walk. Polarization mode dispersion (PMD) has emerged as a key limitation at higher bitrates10Gbpsand above that use even the newest types of fibers due to none zero PMD. Moreover, the system degrading effects caused by PMD are characterized as random stochastic processes that change with many environmental effects [8]. So, it becomes necessary to compensate the effects of the polarization mode dispersion

2. SETUP FOR PMD VARIATION

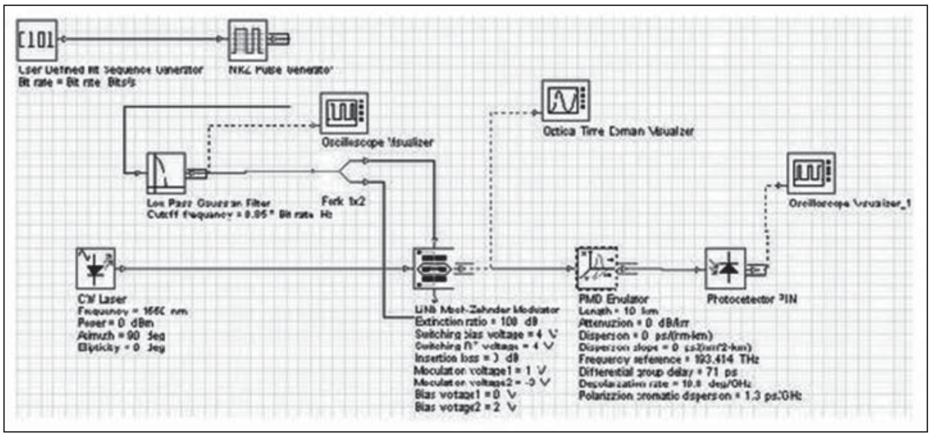

Figure 2 PMD Variation Layout in OptiSystem

3. FIGURES AND RESULTS

The results obtained for polarization dispersion Have been analyzed. The simulations for azimuth = 0 and azimuth = 90 is shown below.

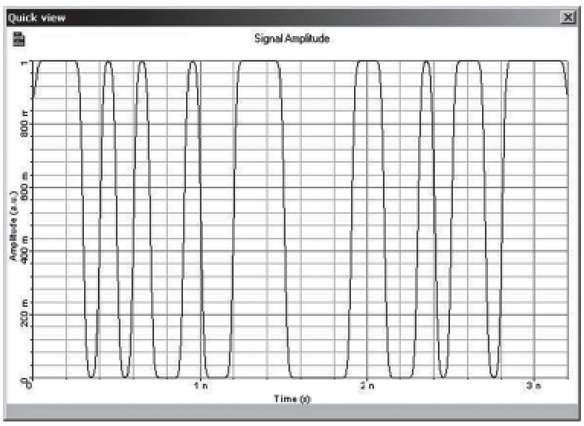

Figure 3. Input signal given

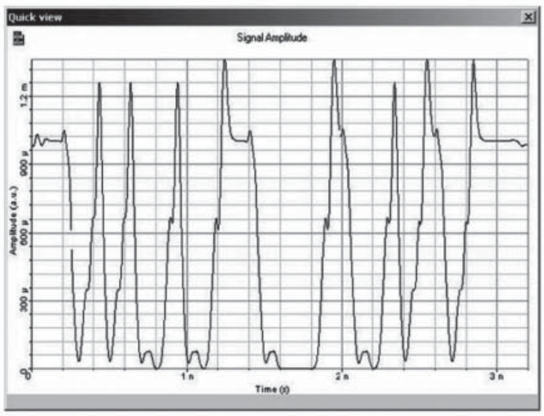

Figure 4. Output for azimuth = 0 and ellipticity = 0

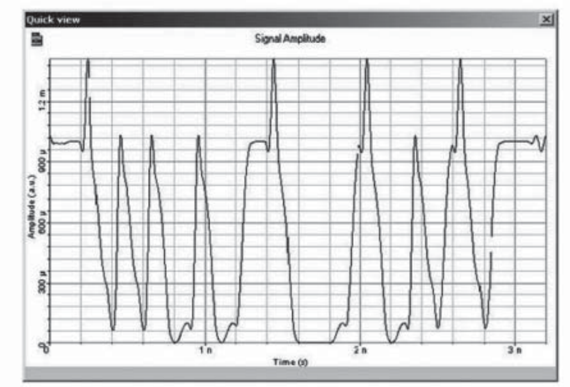

Figure 5. Output for azimuth =9 0 and ellipticity = 0

4. BIREFRINGENCE

Certain environmental conditions such as variations in the temperature and stresses in the fibers can change the refractive index of the fibers. When the temperature increases, the refractive index varies randomly over the wavelengths which results in varying wavelength speeds. Thus the refractive index will have a different value across the horizontal and vertical axis of the fiber core. This difference in the refractive index will result in two orthogonal states of polarization. This will cause *birefringence* in which the light gets split up into fast axis(nx) and slow axis(ny), when a ray of light enters a fiber. This phenomenon is also known as *double refraction.* When the birefringence varies then the PMD also varies randomly.

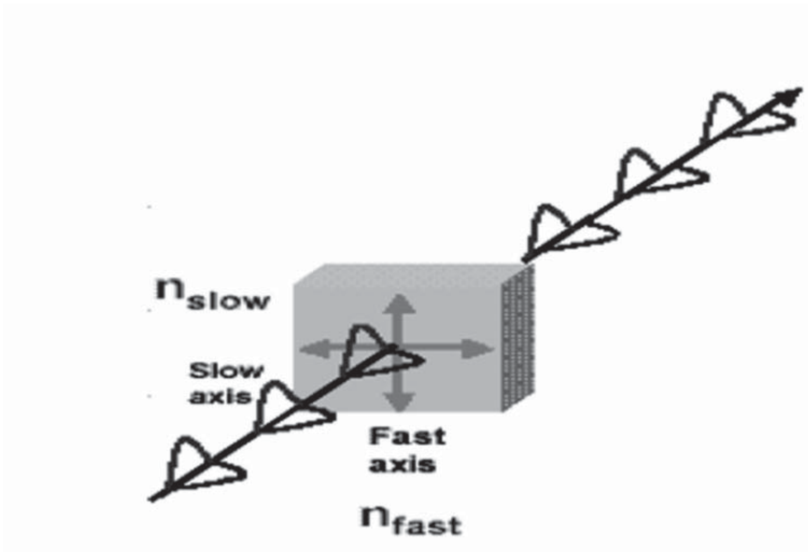

Figure.6. Birefringence Effect

5. DIFFERENTIAL GROUP DELAY

The birefringence effect of the fiber will cause Differential Group Delay (DGD) between the two polarization states. The DGD is nothing but the difference in propagation times between the two polarization states. This differential time delay between the propagation modes is called as first order Polarization Mode Dispersion. Since this delay depends on the frequency and varies over the bandwidth another dispersion factor arises. This will cause further pulse spreading resulting in second order Polarization Mode Dispersion. Further increase in PMD over long distance transmission and high data rate transmission systems, higher order PMD will occur which limits the data rate.

The DGD can be expressedas,

$$\Delta\tau PMD = DPMD * \sqrt{L}$$

Where L is the length of the fiber, D PMD is the amount of PMD incurred in the fiber. It is expressed in terms of ps.

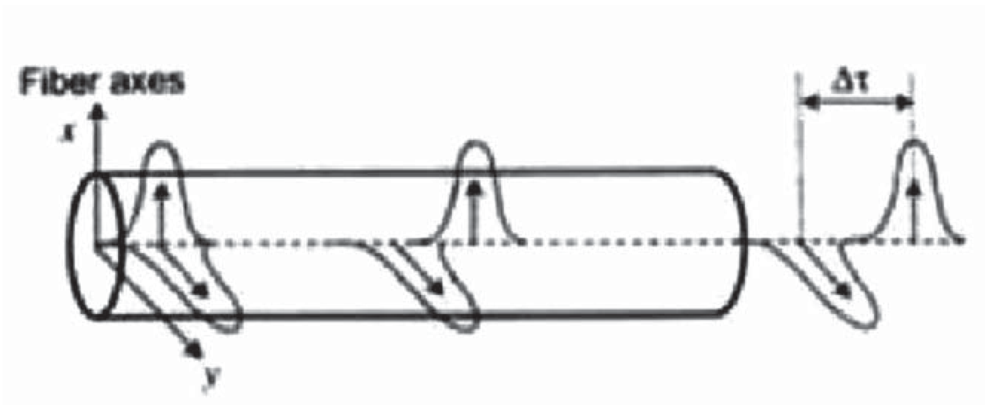

Figure 7. Differential Group Delay Effect

6. PMD COMPENSATION

To support a high-capacity wavelength-division- multiplexing (WDM) transmission, the embedded standard single-mode fiber(SMF) should be up graded to overcome the dispersion limit. In this paper, dispersion compensating fiber is analyzed with dispersion compensation with the help of fiber bragg compensator. According to relative position of DCF and single mode fiber ,post-compensation, pre-compensation and symmetrical/mix compensation is proposed. DCF Pre-compensation scheme achieved is persion compensation by place the DCF before a certain conventional single-mode fiber, or after the optical transmitter. Post compensation scheme achieved is persion compensation by place the DCF after a certain conventional single-mode fiber, or before the optical transmitter. Symmetrical/ mix compensation scheme is consisting of post compensation and precompensation. Different location on the system will generate different nonlinear effects.

7. SIMULATION SETUP FOR PRE, POST AND MIX COMPENSATION

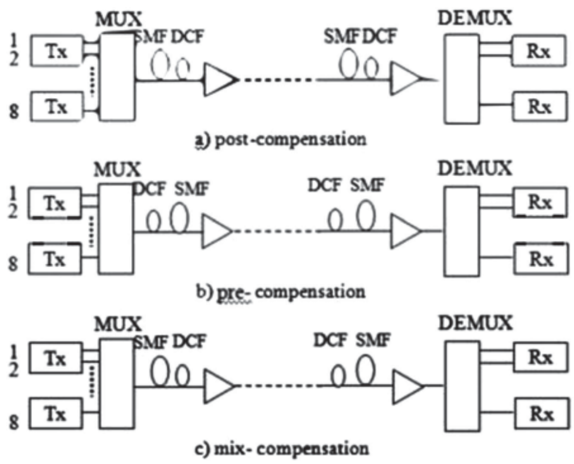

Figure 8. Design setup for different compensation techniques

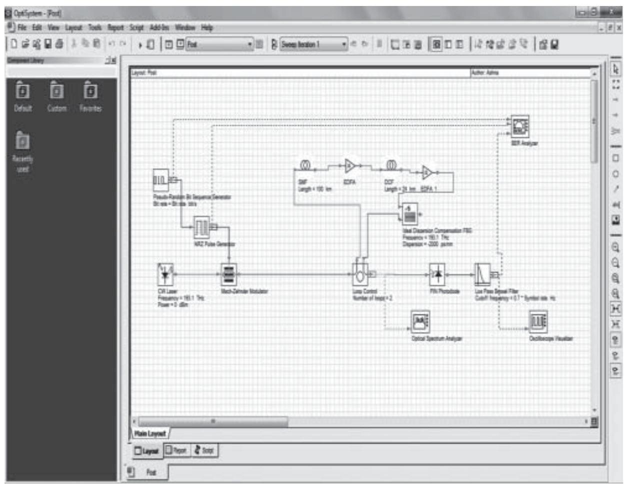

Figure 9. OPT System Layout for Post Compensation

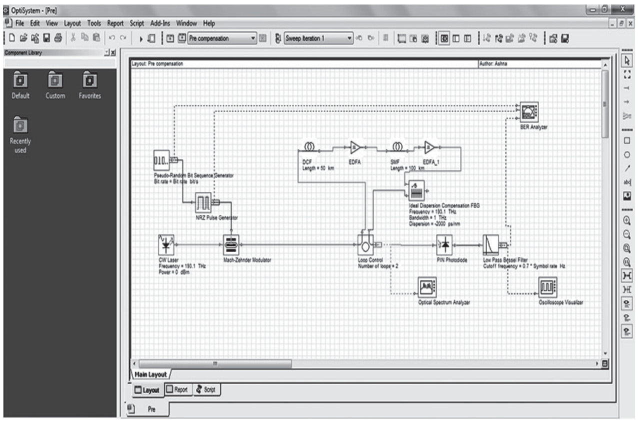

Fig. 10 OPT System Layout for Pre Compensation

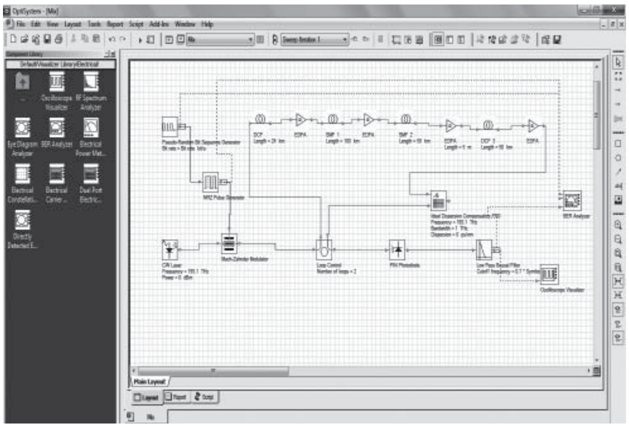

Figure 11. OPT System Layout for Mix Compensation

8. SIMULATIONS

The components in the layout as shown in Fig.9 simulate the real time behavior of the corresponding components. The data source used here is a Pseudo Random Binary Sequence (PRBS) generator. The period of the waveform, duty cycle, amplitude levels and datarates can be set in this generator. The Direct modulator laser component normally simulates a simplified continuous wave laser and a modulator component, which generates a continuous wave of constant amplitude and modulates the signal. Generally a fiber is after all a transmission medium which should bring the same status of the signal (both if the time domain as well as in frequency domain) at the input and output. The fiber in the OPTSIM toolbox generally implements the practical optical fiber. The fiber used in this experiment is of length100km. This fiber is normally a complex structure and all the effects such as attenuation are caused only because of the fiber nonlinearity. So handling of this component is very important. Generally, fiber used Here will be the single mode fiber. Since this layout is meant for PMD analysis and compensation, the parameters corresponding to PMD such as birefringence, polarization effects should be switched ON and where as other nonlinearity effects should be switched OFF. The output from the fiber can be split by means of an optical splitter and can be sent through the polarizer1, delay element and polarizer 2(DDGD) and then combined by using a multiplexer and the required controlled and Optimized parameter settings depending on the bit rate and PMD values can be made here.

After the simulation, the broadened and compensated pulses can be viewed with the help of signal analyzers, which are placed after the fiber and after the multiplexer respectively. The PMD compensation achieved by above method is upto 100psin 10Gbps transmission system.

8. RESULTS AND DISCUSSIONS

Using fiber braggg ratings (FBG) along with DCFat10Gb/sWDM system is an effective solution. It is observed that the compensation schemes reduced the dispersion appropriately but among them post compensation scheme reduced the accumulated fiber chromatic dispersion to the maximum possible extent.The effect of dispersion compensation is very good with -2000ps/nm dispersion compensator of fiber bragg at 0 dB power for post compensation technique. The signal quality is high, eye shape is also better and the effect of dispersion compensation is quite good.

Table1.
Comparison for PMD Compensation Techniques

Technique/Parameter	No Compensation	FBG Compensation	DCF Technique	DCF for long distance
Q-factor	46.9078	52.541	119.745	51.7997
MIN BER	0	0	0	0
Eye-Height	0.00191449	0.00191978	0.00085787	0.00333959

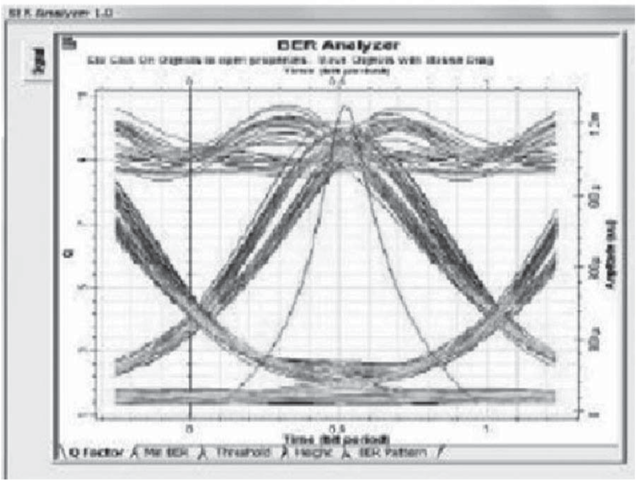

Figure 12. Eye diagram for Post compensation

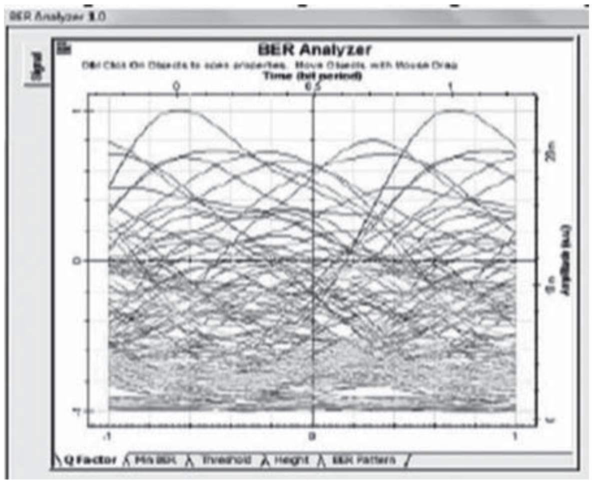

Figure 13. Eye diagram for Pre compensation

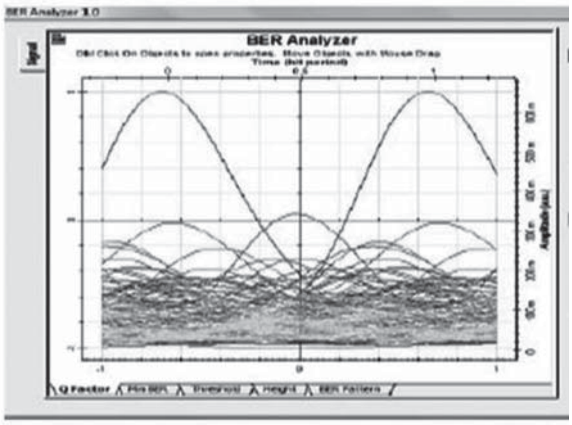

Fig. 14 Eye diagram for Mix compensation

9. CONCLUSION

The effect of changing the value of PMD for four channels is reported in this paper. These effects are seen from the eye diagram drawn for the different values of Polarization Dispersion. It is concluded that any further increase in value of PMD causes great fluctuations in the characteristics of the measured parameters. Therefore, some sort of PMD Compensator is required to filter the adverse effects of Polarization Mode Dispersion (PMD). From the experimental simulation using OPTSYSTEM, the PMD effects are analyzed and compensated efficiently by DCF method. However, this method does not provide completely effective results at very high bit rates. Hence this can be taken as future work.

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