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SELF PHASE MODULATION REDUCTION FOR ERROR-FREE TRANSMISSION OF SIGNAL

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Abstract— *This paper concentrates on the Self Phase Modulation, a type of nonlinear effect on optical fibers. A main objective of this paper is to reduce the Self Phase Modulation (SPM) for Error-Free transmission of the signal. There occurs degradation in the signal quality when the signal is transmitted through an optical fiber. So SPM is reduced for improvement of the system performance. In this paper simulated the result for 25km length of an optical fiber, 2W of transmitted power and 10ps/nm/km of fiber dispersion. In this paper SPM is reduced after the use of Mach Zehnder Modulator. This analysis is done with the help of Optisystem12.0 Software.*

Keywords*-Nonlinear effect, Self Phase Modulation, Mach Zehnder Modulator*

INTRODUCTION

Fiber Optic Communication Systems are the light wave systems that involve optical fibers for information transmission. The most important impairments associated with long distance optical fiber transmission systems that include fiber dispersion, fiber nonlinearities [1]. Earlier some linear effects were faced such as optical attenuation and dispersion in fibers, which can now be easily dealt with using a variety of avoidance, regenerative and cancellation techniques, but nonlinear effects like SPM, XPM and FWM need special attention while designing a fiber optic transmission system [12].

But here focus on the fiber nonlinear effects on the fiber optic communication system. The nonlinear effect occurs in the optical fiber either due to intensity dependence of refractive index of the medium or due to inelastic scattering phenomenon. The intensity dependence of refractive index can lead to nonlinear phenomenon Such as SPM, XPM and FWM. The inelastic scattering phenomenon is SBS and SRS [1].

All these nonlinear effects reduce the system performance. At high power level an intensity change tends to change in the refractive index due to which velocity get change, the phase change is produced by this velocity changes and change in phase produced by pulse itself is known as Self Phase Modulation [8].SPM occurs in signal channel configurations, where it basically converts optical power fluctuations into phase fluctuations in the same wave [11]. Significance of SPM is reduced by maintaining the low power level and increasing fiber core area. But this is not suitable for the efficient transmission with long distance [7].

The SPM effect is weaker in the precompensated link than in the postcompensated link and vice versa. A dramatic spectral narrowing effect was observed in the postcompensated link [15]. Here different values of dispersion, power and distance is used for analyzing the Quality Factor, Bit Error Rate. After the transmission of signal through an optical fiber get distorted by SPM nonlinear effect, so this effect is compensated by comparing the different values of input power and Eye Height value [8].

Optical dispersion is varied from -10ps/nm/km to +10ps/nm/km and obtains constant Quality factor at before Self Phase Modulation, but after Self Phase Modulation, Quality factor becomes nonlinear. It can reduce the SPM up to some extent but not able to completely remove these SPM effect [10]. SPM can significantly increase the pulse broadening effect. In the technique of proper filtering and reduction in effective fiber length is used for reduction of SPM effect. But this is not suitable for long distance transmission. Then only SPM is reduced by choosing the optimized value of fiber core area [7]. In the center area, concentration of the erbium ions are varied from 100 to 2000 parts per million. An active fiber with concentration of erbium ions as high as 5000 parts per million is also available [7].

When SPM is negligible and optical extinction ratio is maximized, the modulator design must be considered carefully in order to increase the transmission distance. When the effects of fiber nonlinearities are negligible, an increase in the dispersion limited transmission distance is obtained for asymmetric Y-branch waveguides. The receiver sensitivity worsens more with increasing fiber length for a preamplified receiver as the dominant source of noises the signal spontaneous beat noise. The system performance strongly depends on the modulator design, transmitted optical power and modulation conditions [6].

SIMULATION LAYOUT DESIGN

In this paper discuss about the reduction of the Self Phase Modulation effect. This is analyzed with the help of the Optisystem12.0 simulation tool. This simulation layout is given in the Figure1. It consists of three sections. The first section is the transmitter section that include with the Bit Sequence Generator and Pulse Generator. Second section contains the Single Mode Fiber which acts as a channel. The channel section provides the some distortion that leads to impairment of the signal through the transmission of the signal.

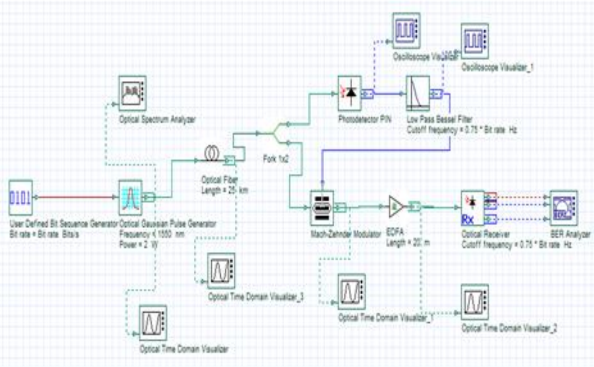

Figure 1.Simulation layout for Self Phase Modulation Reduction

Last section is the receiver section that has the Fork, Mach Zehnder Modulator (MZM), Erbium Doped Fiber Amplifier (EDFA), Photodetector PIN, Low Pass Bessel Filter and an Optical Receiver. Some Visualizer components are also used in this simulation configuration such as Optical Spectrum Analyzer, Optical Time Domain Visualizer and BER Analyzer. In this paper the help of the combination of Mach Zehnder Modulator and EDFA to reduce the effect of Self Phase Modulation.

WORKING PRINCIPLE

In this simulation result a User Defined Bit Sequence Generator is used to provide the data sequence. This data is transferred to the Optical Gaussian Pulse Generator. First section is known as transmitter section, whose task is to generate the input data sequence to the optical channel. An Optical Fiber should contain some properties such as length, attenuation, dispersion and effective fiber area. In this paper 25km length of the fiber is simulated with 2W of transmitted power for Error-Free transmission of signal.

At the receiver section, Fork act as a splitter and it supports any type of signal either electrical or optical signal. In this paper Mach Zehnder Modulator is not used for controlling the amplitude wave. It is used in receiver section for reduction of SPM effect. In generally Photodetector APD is used for achieving the high gain. But in this simulation Photodetector PIN is used for production of the low noise compared with the Photodetector APD. Photodetector basically used for optical to electrical conversion. Low pass Bessel filter is used for maximally flat delay. Optical Spectrum Analyzer estimates the input spectrum by partitioning the total data sequence into various section.BER analyzers produces the Eye diagram that can be used for analyze the performance of the system in an effective way.

RESULTS AND DISCUSSION

An input signal is generated from the simulation results without any distortion at before the fiber section. In this simulation, SPM is reduced at the used as a reference wavelength. Fiber effective area is 80um^2.Optical fiber has the 10 ps/nm/km dispersion value. If use above this dispersion value after the transmission of signal couldn't recover the original signal which means couldn't recover the error-free signal. An Input signal at before the transmission of signal is shown in Figure 2.

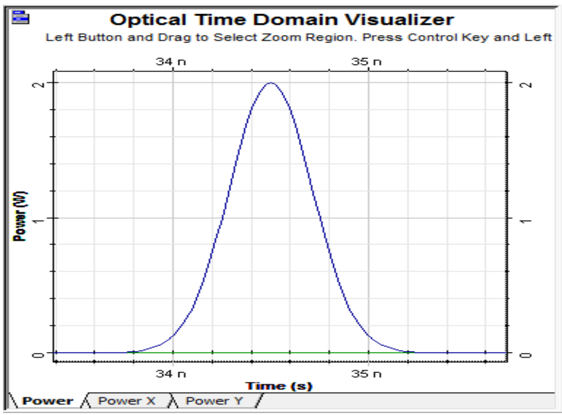

Figure2. Simulation result for before transmission of signal

The 2W of power and 25km length of fiber induces the Self Phase Modulation after the fiber section. After the fiber section SPM is produced by the variation of refractive index due to the transmitted input optical power and length of the fiber.
In this simulation result, if use the above 25km length of the fiber it induces the high level SPM effect and removal of this SPM effect is complicated compared with 25km length of fiber. If use of above 25km, it provide some deviation in signal and doesn't get error-free signal.SPM is available after the transmission of 25km length of the fiber and that is shown in Figure 3.

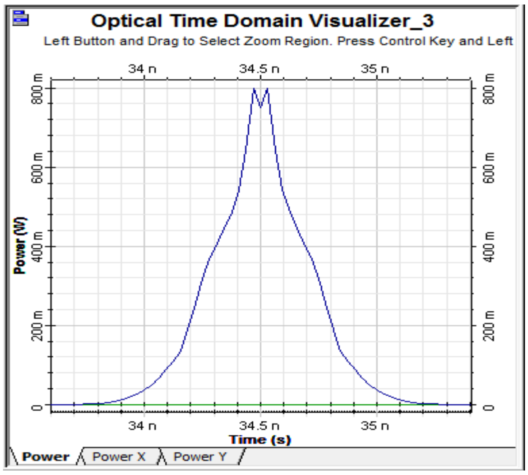

Figure3. Simulation result for after 25km transmission of signal

SPM is used for many applications such as Optical Switching, Soliton Formation but it also reduces the performance of the system. For this reason SPM is reduced without any error for the better performance of the system. In this simulation result, MZM is not only used for either modulation purpose or controlling amplitude of signal and it also used for reduction of SPM effect. Reduction of SPM occurred after using Mach Zehnder Modulator that is shown in Figure 4.This signal is suitable for transmission up to 25km distance without distortion through this transmission system.

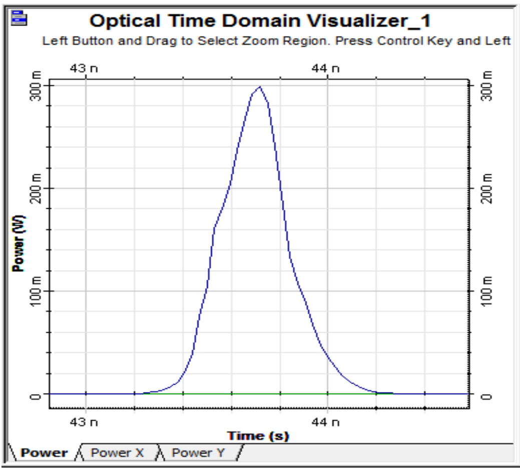

Figure 4.Simulation result for reduction of SPM effect after using MZM

In Figure 4 shows an error-free transmission of signal which means it does not have a Self Phase Modulation effect during the transmission of signal through an optical fiber. In this simulation result, some deviation is occurred but SPM effect is neglected. After using this EDFA the signal gets amplified then it also provides the improvement of Q-factor and Eye Height. In Figure 5 shows the reduction of SPM effect after using EDFA that is like as using the MZM, but in EDFA performance is improved compared with MZM.

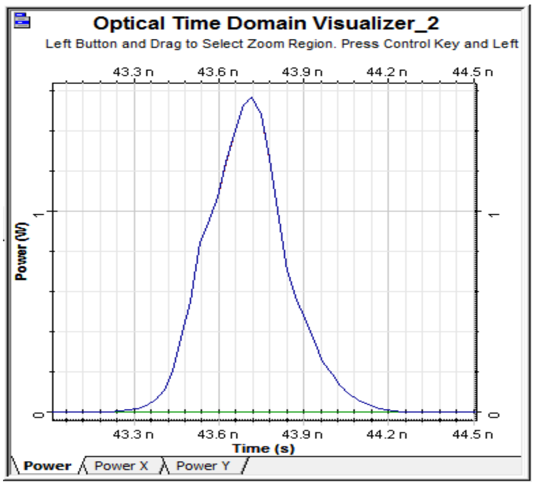

Figure 5.Simulation result for after using EDFA

Here the EDFA is used for reduction of SPM effect with improvement of the system performance. In this EDFA has the same core radius and erbium core radius which is 2.2um. Erbium ion density is 1000ppm~wt. 20m length of EDFA is used in this simulation and 980nm pump wavelength is involved in this properties of EDFA. Because it generates the low noise and high gain compared with 1450nm pump wavelength.

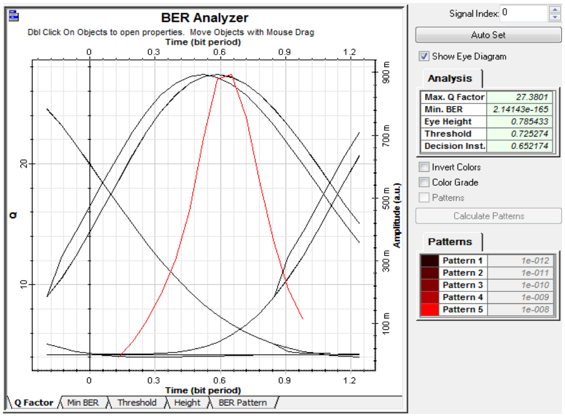

Figure 6.Eye diagram result for reduction of SPM effect

From this eye diagram 27.3801 of Q-factor and 0.785433 of Eye height is obtained. These are useful for analysis of the system performance.

CONCLUSION

In this paper reduction of Self Phase Modulation effect on the fiber is reported. This is concluded that for successful transmission depends on the approximate condition of the Mach Zehnder Modulator and Erbium Doped Fiber Amplifier. This simulation layout is suitable for the 25km length of the fiber for reduction of SPM. From this results, when input power and fiber length is increased while Q-factor and Eye height is decreased. The corresponding Q-factor is 27.3801 with minimum BER of 2.14743e-165. If try to decrease the BER, couldn't obtain without distortion of Eye diagram.

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