



Effect of Self Phase Modulation on Optical Fiber

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ABSTRACT:- This paper shows the effect of Self Phase Modulation, a type of nonlinearity on optical fibers. In this paper we have taken the optical fiber of length 100kms. We will analyze the Quality Factor at different values of optical dispersion. We will vary the optical dispersion from -10ps/nm/km to 10ps/nm/km and we will see that before Self Phase Modulation the Q-Factor is constant, but after Self Phase Modulation, the Q-factor becomes nonlinear. We will see the difference in Q-factor with the help of eye diagrams and subsequent graph. All the results are analyzed using OPTSIM simulation at 10 Giga bits per second (Gb/s) transmission systems.

Keywords: SPM, DISPERSION, NON LINEARITIES, OPTSIM, Q-FACTOR

I. Introduction

Nonlinearity effects arose as optical fiber data rates, transmission lengths, number of wavelengths, and optical power levels increases. The only worries that plagued optical fiber in the early day were fiber attenuation and, sometimes, fiber dispersion, however, these issues are easily dealt with using a variety of dispersion avoidance and cancellation techniques. Fiber nonlinearities present a new realm of obstacle that must be overcome. These nonlinearities previously appeared in specialized applications such as undersea installations. However, the new nonlinearities that need special attention when designing state-of-the-art fiber optic systems include stimulated Brillouin scattering (SBS), stimulated Raman scattering (SRS), four wave mixing (FWM), self-phase modulation (SPM), cross-phase modulation (XPM), and intermodulation. Fiber nonlinearities represent the fundamental limiting mechanisms to the amount of data that can be transmitted on a single optic fiber. System designers must be aware of these limitations and the steps that can be taken to minimize the detrimental effects of fiber nonlinearities[1,2,3].

II. Self Phase Modulation (SPM)

Self-phase modulation (SPM) is a nonlinear optical effect of light-matter interaction. An ultrashort pulse of light, when travelling in a medium, will induce a varying refractive index of the medium due to the optical Kerr effect[4,5]. This variation in refractive index will produce a phase shift in the pulse, leading to a change of the pulse's frequency spectrum. Self-phase modulation is an important effect in optical systems that use short, intense pulses of light, such as lasers and optical fiber communications systems[6].

III. Simulation Setup

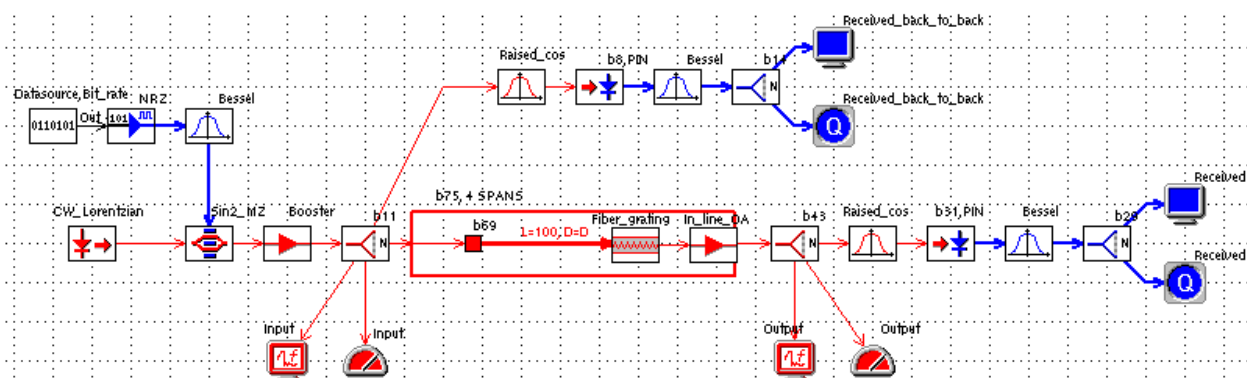


Fig. 1.1 Simulation Setup for Self Phase Modulation using OPTSIM

The figure (1.1) shows the simulation setup for the analysis of Self Phase Modulation in optical link having single channel. The SPM is analysed for six values of dispersion from -10ps/nm/km to 10ps/nm/km. The transmitter and receiver section are connected by the dispersive fiber link. The transmitter section consists of data source, modulator driver, laser source and modulator. Data source produces a pseudo-random sequence of bits at a rate of 10Gbps. The output of data source is given to modulator driver which produces a NRZ (Non return to zero) format pulse train. The transmitted signal is formed by modulating the light carrier by the NRZ data source. confinement factor is 0.35, insertion loss is 3 dB and output insertion loss is 3 dB. The various parameters for RAMAN are Raman fiber length is 10 km, operating temperature is 300 K, pump wavelength is 1480 nm and pump power is 300 mW. The light carrier is generated by Lorentzian laser source at the 1550 nm wavelength. The transmitter output is boosted up by the fixed gain Erbium Doped Fiber Amplifier (fixed_output_power).

There are two types of optical amplifiers; Semiconductor Optical Amplifier (SOA) and the Erbium Doped Fiber Amplifiers (EDFA). Due to its high gain characteristics EDFA are used these days. The shape of the gain graph is flat having a gain of 25 dB. The noise figure value is set at 4.5 dB. The transmission medium used is a standard single mode fiber of 100kms length. The receiver used in the system is the PIN (Receiver, PIN) receiver, which uses the PIN (p-intrinsic-n) diode as a detector. The pin photodiode simulated had 70% quantum efficiency. The dark current was simulated at 0.1 nA. The output of the receiver is given to the measurement devices which are fed through the electrical splitter, the electrical scope and the Q estimator. The optical spectrum of the signal is observed from optical spectrum analyzer (input and output) by splitting the signal from fiber link with the use of optical splitters. Firstly we will analyse the Q-factor using simple single mode fiber without using dispersion effect and then we will compare it with Q-factor obtained after using dispersion effects.

IV. Figures and Results

The figure 1.2 to 1.7 below shows the eye diagrams and corresponding value of Q-factor for the different values of optical dispersion. We have shown two eye diagrams in each figure one is without the effect of Self Phase Modulation (SPM) and the other one is due to the effect of Self Phase Modulation (SPM). In the figures we will see that as we varies the dispersion due to the effect of Self Phase Modulation (SPM) the Quality factor becomes nonlinear. In figure 1.8 we have compared both the techniques with the help of a graph.

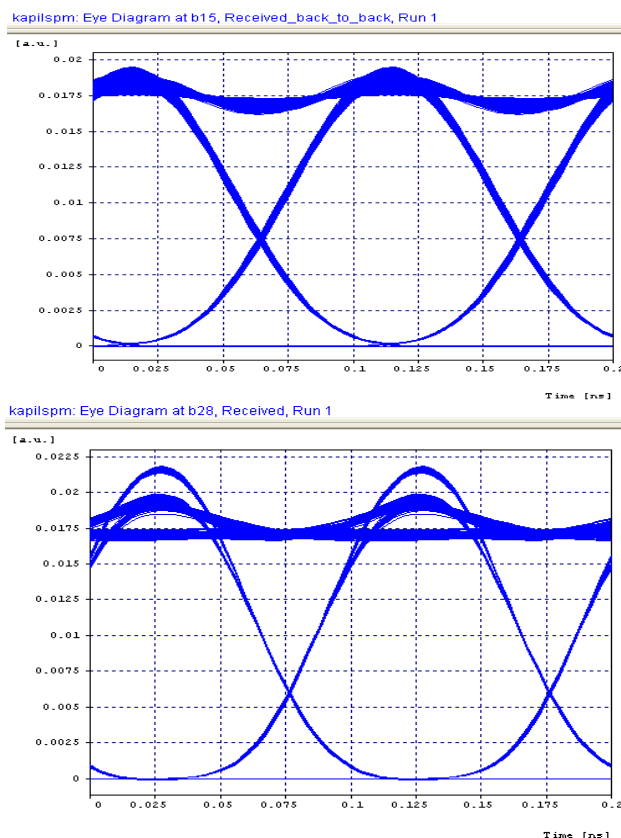


Fig 1.2: Eye Diagram for optical dispersion at -10ps/nm/km (a) Eye diagram before Self Phase Modulation (b) Eye diagram after Self Phase Modulation

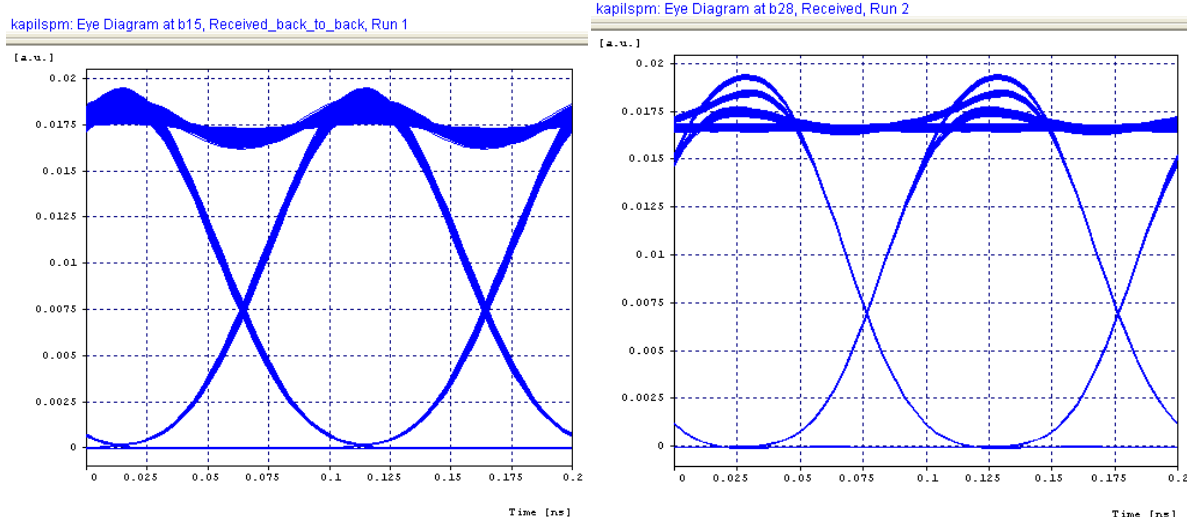


Fig1.3: Eye Diagram for optical dispersion at -5ps/nm/km (a) Eye diagram before Self Phase Modulation
(b) Eye diagram after Self Phase Modulation

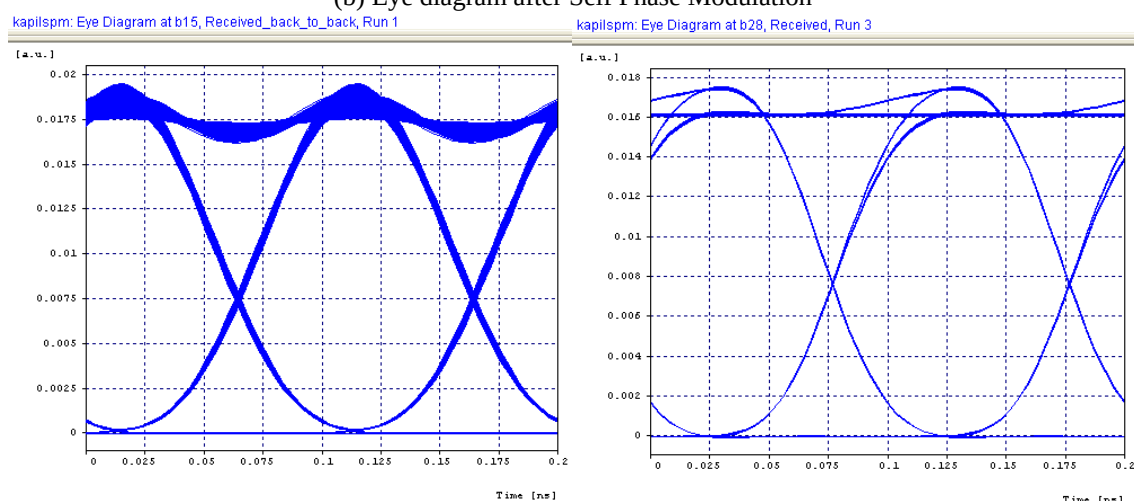


Fig 1.4: Eye Diagram for optical dispersion at -1ps/nm/km (a) Eye diagram before Self Phase Modulation
(b) Eye diagram after Self Phase Modulation

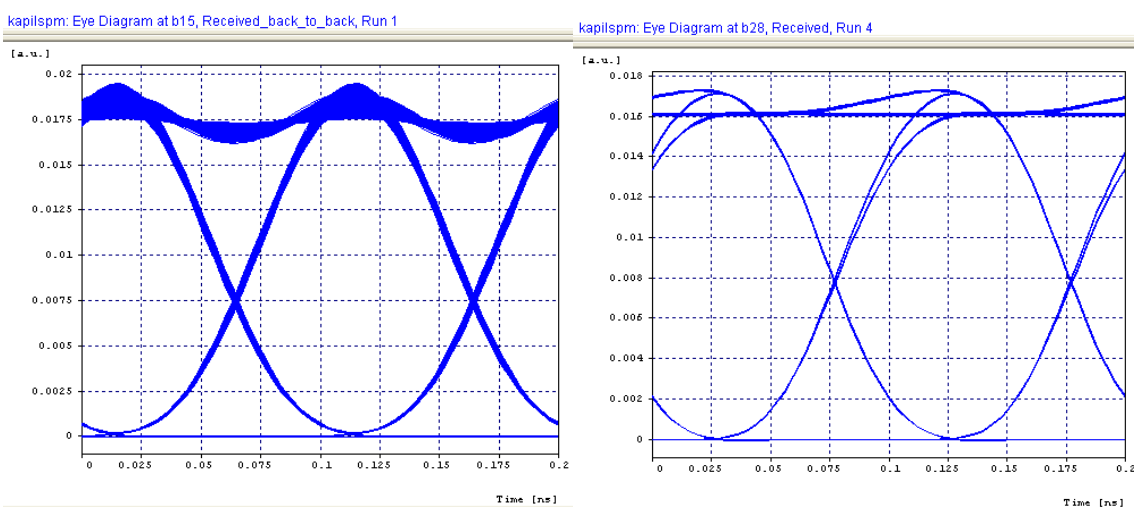


Fig 1.5: Eye Diagram for optical dispersion at 1ps/nm/km (a) Eye diagram before Self Phase Modulation
(b) Eye diagram after Self Phase Modulation

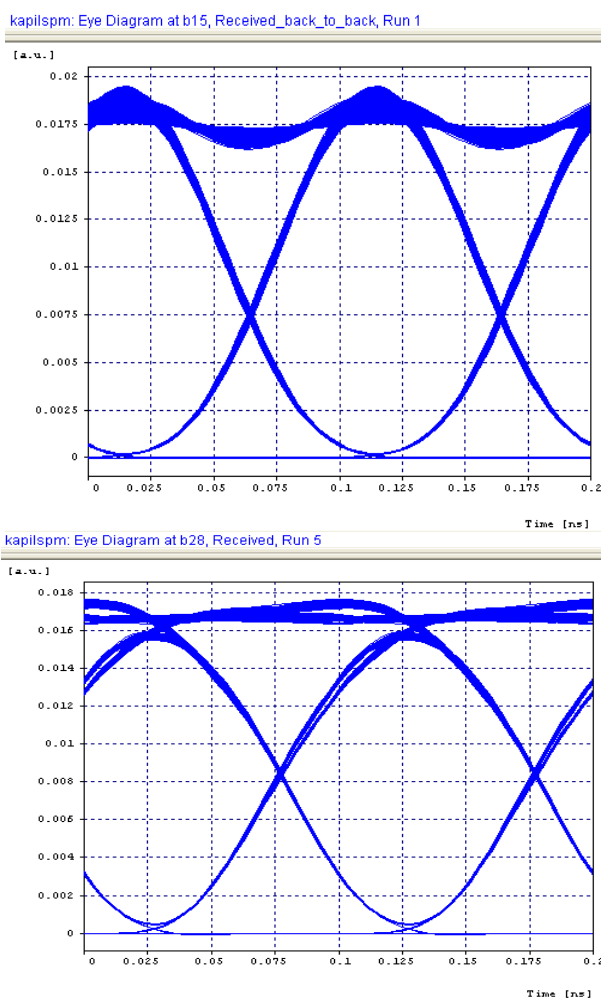


Fig 1.6: Eye Diagram for optical dispersion at 5ps/nm/km (a) Eye diagram before Self Phase Modulation (b) Eye diagram after Self Phase Modulation

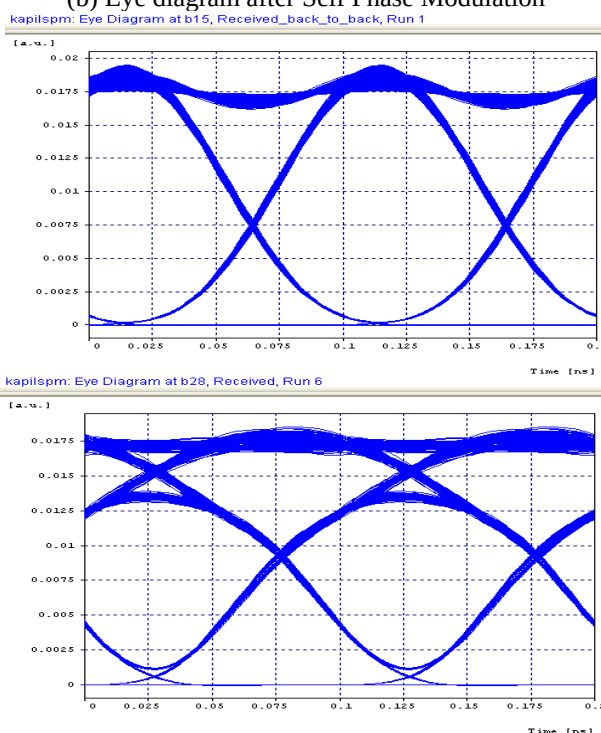


Fig 1.7: Eye Diagram for optical dispersion at 10ps/nm/km (a) Eye diagram before Self Phase Modulation (b) Eye

diagram after Self Phase Modulation

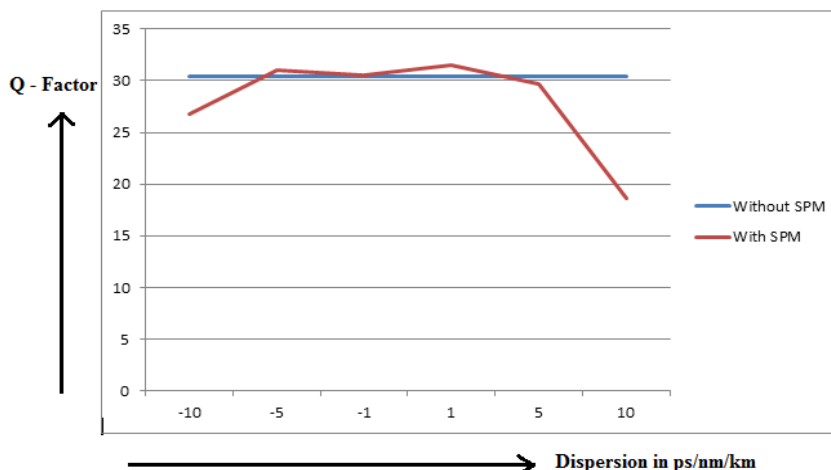


Fig 1.8: Graph for Quality factor versus dispersion with Self Phase Modulation (SPM) and without Self Phase Modulation (SPM).

V. Conclusion

The effect of Self Phase Modulation on optical fiber is reported in this paper. These effects are seen from the eye diagrams drawn for the different values of dispersion. Furthermore the graph for the Quality Factor at the different values of optical dispersion is also drawn. The above discussed results show that due to Self Phase Modulation (SPM) the Quality Factor becomes nonlinear. We can reduce the Self Phase Modulation up to some extent but we are still not able to completely remove the Self Phase Modulation from the optical fibers especially at higher bit rates, which is a topic of research and a challenge for the various scientists in the optical fiber field.

VI. References

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