Factors Affecting Higher Order Solitons in Soliton Transmission

SUBI S, Lakshmy G B

P.G. Scholar, Optoelectronics and Communication Systems

Dept. of ECE

TKM Institute of Technology, Kollam. India.

Subi.sulaiman@gmail.com

Abstract— Transmission of solitons at data rate of Tb/s effected by different factors. In this Paper, we analyzed some of the effects like third order dispersion effect , stimulated raman scattering and self-steeping and their influence on higher order solitons in soliton transmission through optical fiber.

Keywords— Intrapulse Raman scattering (IRS), Silicon-on-Insulator (SOI),Third Order Disperssion (TOD).

INTRODUCTION

In fibers, solitons were first observed by Mollenauer [1]-[2] and several authors have discussed the applications of solitons in future for high-transmission-rate communication system [3]-[5]. In the third-order dispersion helps in determining the required soliton power levels with limiting the bandwidth of the system [6]. The effects of higher-order dispersion on soliton propagation and pulse broadening with breakup in the time domain has also been shown [7]-[8].Demonstration of stable propagation of dispersion-managed solitons with zero average dispersion has been experimentally done [9]. Analytic solutions for the nonlinear Schrödinger equation model with changing dispersion, nonlinearity, and gain or loss were presented [10].In SOI waveguides some Parametric investigations have been carried out to control the TOD effect on the generation of optical solitons [11].Full numerical simulation of the nonlinear Schrödinger equation has been done to identify influence of higher order terms on pulse propagation [12]. At high transmission rate as at 100 Gb/s and beyond intrapulse Raman scattering (IRS), third order dispersion and self-steeping effects can become very appreciable [13].with periodically modulated core diameter the impact of stimulated Raman scattering in the fiber on the fission of high-order solitons has been done [14]. Intrapulse Raman scattering may result in slowing and stopping if solitons [15]. Dynamics of dual-frequency solitons under the effect of frequency-sliding filters, intrapulse Raman scattering and third-order dispersion has also been studied [16]. For high speed data transmission through fiber, our other simulative analysis for optical telecommunication has been recently done [17]-[22].

SIMULATION SETUP

The simulation setup for studing the higher order soliton in the presence of different effects is shown in Fig.1. A user defined bit sequence is generated at the rate of 4×10^{10} bits/s and sample rate of 512×10^{10} Hz. Here samples per bit are 128 with 1024 number of samples for studying TOD and changed to 2048 samples per bit with 4096 number of samples for stimulated raman scattering and self-steeping. This bit sequence is given to the soliton optical pulse generator working at the frequency and power of 1272.54nm and 105.394mW respectively. Output waveforms are analyzed using optical spectrum analyzer and time domain visualizer. Nonlinear dispersive fiber with the effects of third order dispersion and group velocity dispersion is taken for transmitting data. Allowed maximum nonlinear phase shift is 40mrad. Dispersion parameters β_2, β_3 re taken as - 0.217825ps^2/km and 0.0744876ps^3/km .Self-phase modulation is also taken into account. Dispersion of 16.75ps/nm/km and attenuation of 0.2db/km is there. Avalanche photodiode is used at the receiver to detect optical pulse and convert it into electrical form. For further analysis electrical visualizers can also be used. The outputs at the receiver are observed with different optical analyzers.

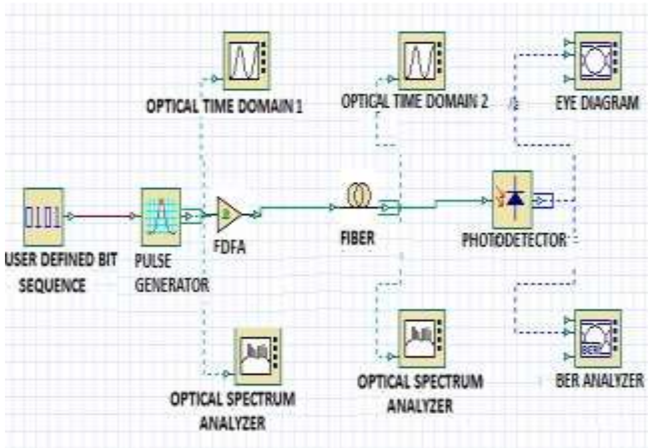
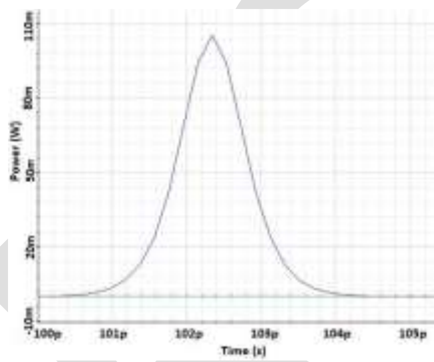


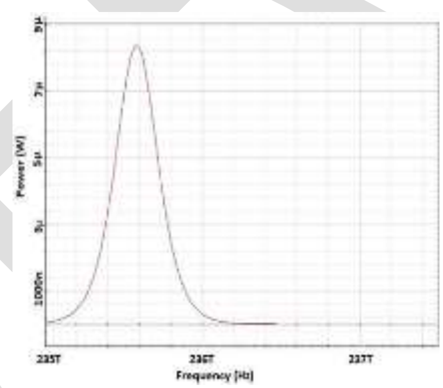
Fig.1 Simulation Setup for the study of different effects on higher order

RESULTS

The input pulse shape shown in figure in the Fig.2. It is a 1 ps wide (FWHM) fundamental soliton propagating near the zero-dispersion wavelength.



(a)



(b)

Fig.2 Input pulse shape (a) and spectrum (b)

The output pulse shape and spectrum are shown in Fig.3. Output (at 10 soliton periods) pulse shape (c) and spectrum (d) are shown. Resonance radiation peak is evident.The principal effect of the third-order dispersion term is to stimulate radiation resonantly at a frequency [8]:

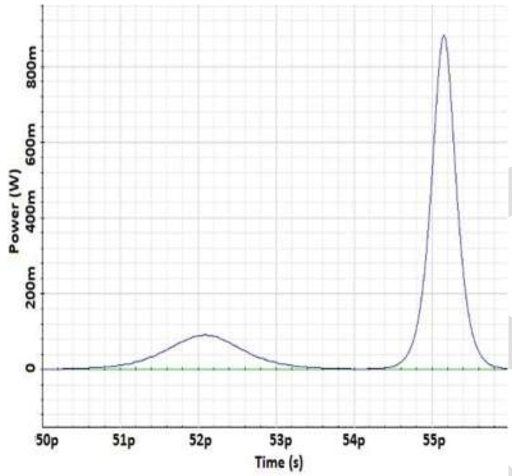
$$\omega-\omega_o = k.|\beta_2|/\beta_3$$

whereβ_2,$\beta_3$are dispersion parameters and k is some constant (generally k is taken as 3).

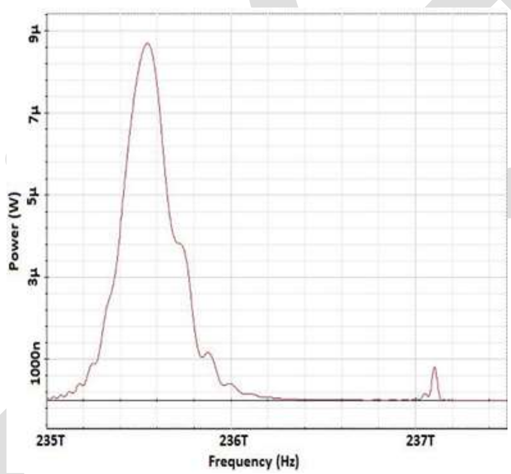
Fig. 4 shows the influence of stimulated Raman scattering on soliton pulses.The effect of stimulated Raman scattering on the higher-order soliton is to break it into its parts.The delayed response of Raman scattering effects the nonlinear response function and also allows extending the investigation for pulse time widths under 1 ps, ranging from 10 to 1000 fs. The starting point is the nonlinear response function $R(t)$, written as [22] :

$$R(t)=(1-f_R)\delta(t)+f_R h_R(t)$$

Where $\delta(t)$ indicates the delta function , f_R is the fractional contribution of the delayed Raman response to nonlinear polarization and h(t)is responsible for the Raman gain spectrum.



(c)



(d)

Fig.3 Output pulse shape (c) and spectrum (d) at 10 soliton periods as a result of TOD effect.

Next we will consider self-steepening effect on solitons. While the soliton splitting has occurred within a distance of five soliton periods in the case when the intrapulse Raman scattering effect is present, the splitting is still in its initial stage (for the same input configuration) here.

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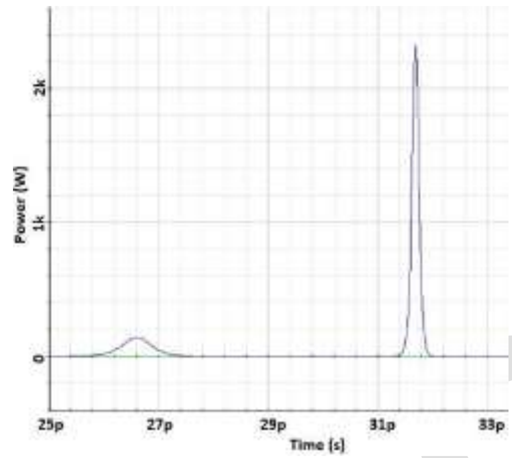
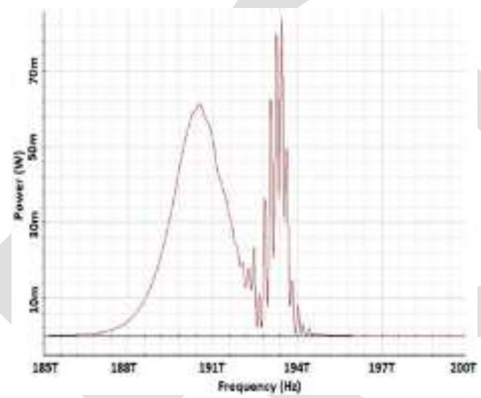
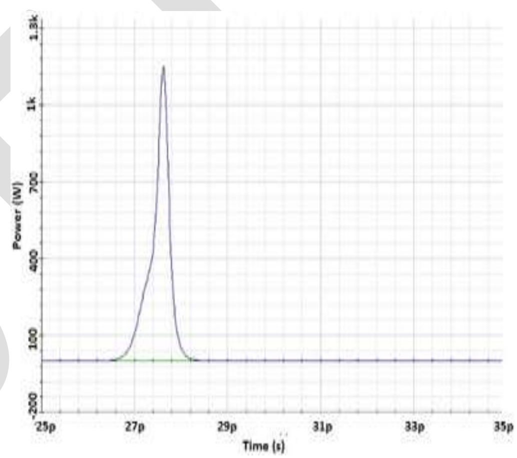


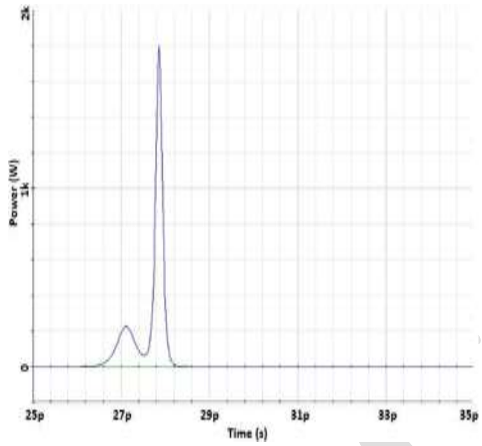
(e)



(f)



(g)



(h)

Fig.5 Output pulse shape at five (g) and ten (h) soliton periods because of self-steeping effect.

The self-steepening effect is weaker than the stimulated Raman scattering.Fig.5 shows the effect of presence of self-steeping on higher order solitons.

CONCLUSIONS

For high transmission of data in soliton transmission TOD, self-steeping and stimulated Raman scattering results in decaying of higher order solitons. TOD leads to stimulate radiation resonantly where as influence of other two on the higher-order soliton is to split soliton into its fractions.

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