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Performance Evaluation of All Optical 2R Regenerators Based on Four Wave Mixing

Merlin Philip[1], Pratheesh P.[2]

[1]P.G.Scholar, Department of ECE, TKM Institute of Technology, Kollam, Kerala, India

[2]Assistant Professor, Department of ECE, TKM Institute of Technology, Kollam, Kerala, India

Abstract: ***An optical signal propagates through a transmission link comprised of fiber and various components,the signal becomes degraded by various impairments such as Amplified spontaneous emission noise, dispersion, and fiber nonlinearities. In order to transmit the optical signal at longer distance, the signal should be regenerated in the intermediate nodes by cleaning up the accumulated noise and distortion. An all optical regenerator is an effective way to overcome these limitations. In this paper, All optical 2R regenerator is designed based on four wave mixing. The performance of regenerator is analyzed using power transfer function, BER measurement etc. The 2R and can be simulated using a commercial optical system simulator named OptiSystem 12.0 by Optiwave.***

Keywords: All optical regenerator, Amplified Spontaneous Emission noise, BER, Four wave mixing , Power transfer function.

1. Introduction

Optical signals transmitted through optical networks are degraded a lot due to addition of noise in optical amplifiers, crosstalk in switches, and nonlinear effects, and dispersion in the fiber etc. Regeneration of the signals is therefore sometimes necessary between transmitter and receiver and this is so far still mainly done using detection, electronic regeneration, and retransmission. But, such a solution is power consuming and inefficient for long haul optical networks.

An all optical regenerator is an effective way to overcome these limitations. Optical regeneration can be performed in three ways; reamplification, reshaping, and retiming. If reamplification is performed using an optical amplifier, it is called 1R regeneration. If reamplification and reshaping are performed, it is called 2R regeneration. When retiming function is added, it becomes 3R regeneration. Thus an optical regenerator restore the signal with same quality as that of input signal. All optical 2R regenerator is an important element in communication system to increase transmission performance.

2. Principle of 2R Regenerator

2R regeneration is considered to be 1R regeneration together with noise suppression and digital reshaping with no clock recovery. This is applicable to individual channels and can be used for different bit rates .To reduce errors, it is useful to reshape the pulse to produce realignment for all the components contained in the optical signal. Therefore, in addition to reamplification, reshaping(ie;2R) is also required to obtain high performance over long transmission distances.

Reshaping of the digital signal can be accomplished using a decision circuit implemented through the use of a Non Linear optical Digital Gate (NODG). Fig.1 shows the schematic diagram of a 2R regenerator. It consists of a local Continuous Wave (CW) source and an optical amplifier which amplifies the incoming noisy data signal. This amplified signal is used to drive a nonlinear gate which impresses the data pattern on the local CW beam. A nonlinear gate is nothing but a nonlinear element (for e.g. HNLF, SOA or VCSEL) in combination with an Optical Band Pass Filter(OBPF).

3. All Optical 2R Regenerators Based on Four Wave Mixing

Four waves mixing is a nonlinear effect used for signal regeneration. Four wave mixing is an inter modulation phenomenon where the interaction of more than two optical signals with different frequency co-propagate along a nonlinear medium, new frequency components can be generated due to the modulation of the refractive index at different frequencies. One of the application of Four wave mixing in communication systems is regenerators.

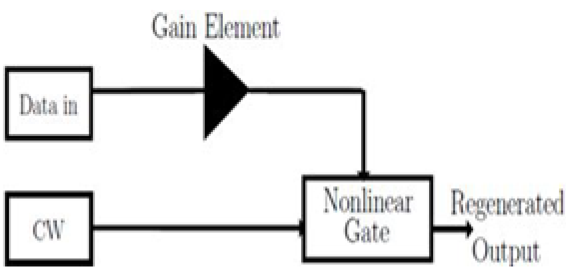


Figure 1: Schematic diagram of a 2R regenerator

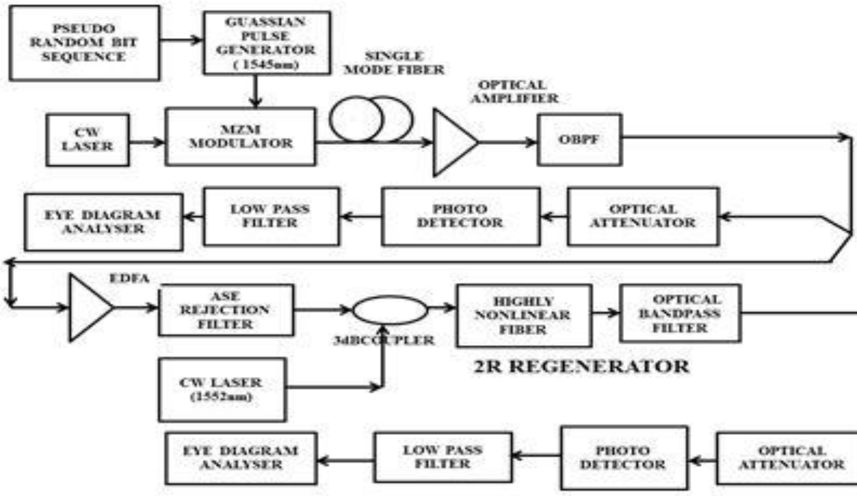


Figure 2: Block diagram to analyse the effect of all optical 2R Regenerator based on FWM

Fig.2 shows the block diagram of all optical 2R regenerator based on four wave mixing. It consists of a continuous wave signal transmitted at frequency f_{cw1} and the signal to be regenerated, propagating at frequency f_{s1}, are co-polarized and coupled into HNLF, where they co-propagate whilst FWM takes place. The noisy signal needs to be previously amplified before being coupled into the fiber to serve as a modulated pump. At the fiber output, first order FWM products (or sidebands) will be found. Optical band pass filter acts as a reshaping unit. It should be set such that it selects the signal and rejects all idlers to minimize signal degradation of the information contained in signal phase.

4. System Design

Fig.3 shows the simulation layout of all optical 2R regenerator based on four wave mixing. All optical 2R regenerator based on FWM consists of transmitter, signal degradation stage, signal regeneration stage, and receiver stage. Transmitter consists of a pseudo random generator, guassian pulse generator, continuous wave laser and Mach-Zehnder amplitude modulator. Pseudo random bit sequence generator generate bit sequence at a bit rate of 2.5Gb/s. CW signal modulate the data by Mach-Zehnder amplitude modulator at a wave length of 1545nm.

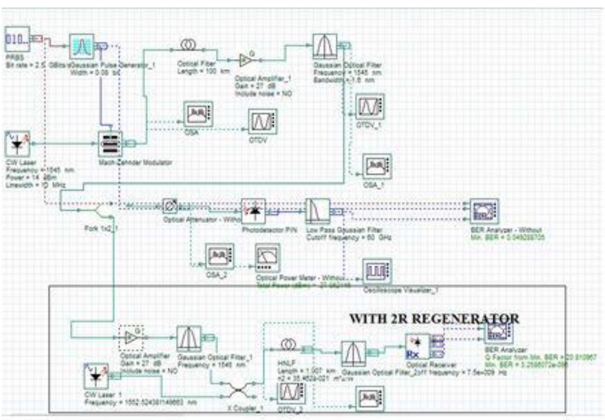
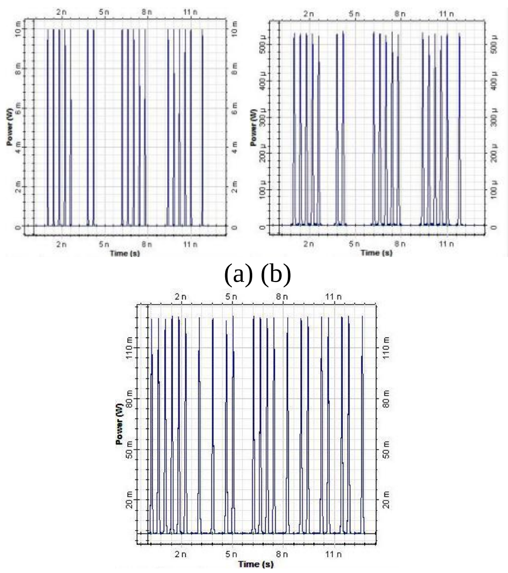


Figure 3: Simulation layout to analyse the effect of all optical 2R Regenerator based on FWM

Input power is set at 10dB. Single mode fiber of length 100Km is used for transmitting the signal. Optical amplifier of gain 27dB is used for amplify the signal.Two guassian optical bandpass filters are used at a wavelength of 1545nm and 1552nm.

Optical amplifier of gain 27dB is used for amplify the signal.Two guassian optical bandpass filters are used at a wavelength of 1545nm and 1552nm.The regenerator stage consists of opticalamplifier of gain 27dB, HNLF of length 1.007Km and have a nonlinear refractive index of $38m^2W$. Another CW signal is generated by at frequency of 1552nm. A 3dB coupler is used to couple the amplified signal. At the receiver stage consists of optical revceiver of cutoff frequency 7.5e-009 and BER analyser. The eye diagram analyzer gives the value of maximum Q factor, minimum BER, eye height and threshold.

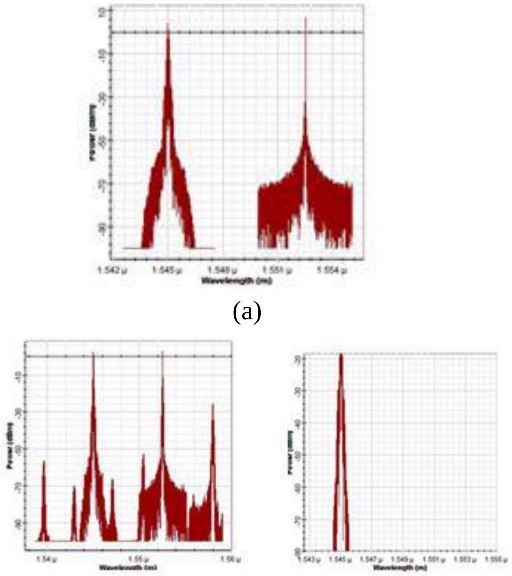
5. Results and Discussions



(a) (b)

(c)

Fig.4: (a) input signal (b) degraded signal (c) regenerated signal



(a)

(b) (c)

Fig.5:(a) input signal (b)signal at the output of HNLF due to FWM (c)regenerated signal

Fig.4 shows the spectrum of input signal at a bit rate of 1.5Gb/s at an input power of 10dBm. After the signal passing through a single mode fiber of length 100Km ,signal became degraded and is shown in Fig.4(b) and by using 2R regenerator, signal became regenerated and is shown in Fig.4(c).

Fig.5 shows the spectrum of input signal and interaction of two signals due to four wave mixing in HNLF results additional two signals and is shown Fig.5(b) and and OBPF reshape the signal and the regenerated signal is shown in Fig.5(c).

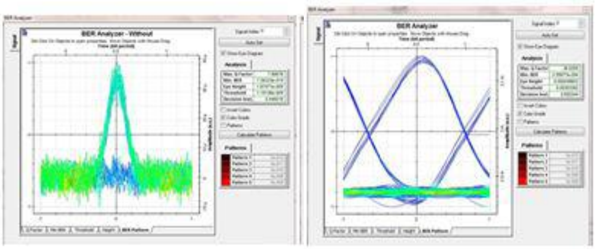


Figure 6: a) Degraded eye diagram (b) eye diagram with 2R regenerator at 2.5Gb/s

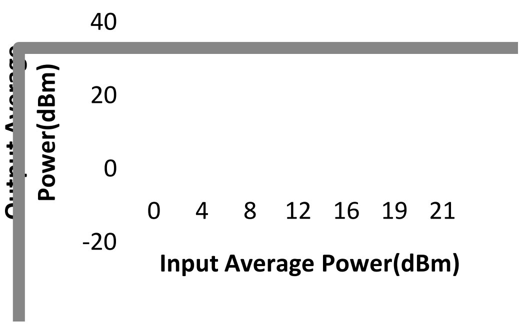


Figure 7: Power transfer function of all optical 2R regenerator

Fig.6: shows degraded eye diagram after the signal propagating in 100Km fiber. The degraded signal having a Q factor of around 7. Eye diagram of the signal regenerated by 2R is shown in Fig.6 (b). It shows that eye opening increases, Q factor increases to 36.

Fig.7 shows the power transfer function of all optical 2R regenerator.At low power,output power is constant.Again ,the power is increased above a threshold value,output power is constant.It shows that low noise and high noise is suppressed at low power and high power respectively.

6. Conclusion

All optical 2R regenerator based on four wave mixing is implemented. Analysis is done using eye diagram and power transfer function. All-optical 2R regenerators based on four wave mixing have improved Q factor of around 36 and is efficient for multi wavelength operation.

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