Performance Evaluation of All Optical 2R Regenerator Based on Self Phase Modulation

Merlin Philip
P G Scholar, Optoelectronics and Communication Systems,
Dept. of ECE
T K M Institute of Technology
Kollam, India

Pratheesh P
Assistant Professor,
Dept. of ECE,
TKM Institute of Technology,
Kollam, India

***Abstract*— 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. In this paper, All optical 2R regenerator is designed based on self phase modulation. 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 2R regenerator,Power transfer function,self phase modulation**

I. INTRODUCTION

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 (ASE) noise, dispersion, and fiber nonlinearities. Inorder 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. 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 unction is added, it becomes 3R regeneration. Thus an optical regenerator restore the signal with same quality as that of input signal.

Self phase modulation based 2R regenerator was proposed by Mamyshev in 1988.Thus Self Phase Modulation(SPM) based 2R regenerator got the name Mamyshev 2R regenerator.This regenerator suppresses the noise in 0 bits and the amplitude fluctuations in 1 bits of Return -to –Zero (RZ)optical data streams. SPM based 2R regenerator can be operated at 10Gb/s,40Gb/s. In this regenerator, dispersive effects within the fiber cannot be ignored and is desireable to operate the regenerator in normal dispersion regime.

II. 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, inaddition 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).

III. ALL OPTICAL 2R REGENERATORS BASED ON SELF PHASE MODULATION

Fig.2 shows the block diagram of all optical 2R regenerator based on self phase modulation. It consists of optical amplifier, ASE rejection filter, highly nonlinear fiber, optical band pass filter. The degraded optical pulse streams are first fed into an optical amplifier which is used to boost the power to a suitably high level at the input to the Highly Non Linear Fiber (HNLF).An ASE rejection filter is used to remove the ASE noise in the signal.

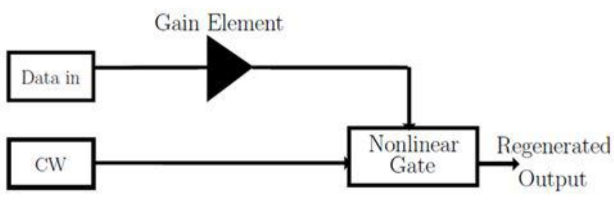

Fig.1: Schematic diagram of a 2R regenerator

The amplified pulses are then propagated in the HNLF during which they experience spectral broadening due to kerr induced self phase modulation. HNLF produces SPM induced spectral broadening only when the signal reaches high enough peak power.

Optical Band Pass Filter(OBPF) acts as a reshaping element. The reshaping function depends on the spectral broadening and position of offset filtering. The broadening spectrum is directly proportional to the intensity of optical pulse. When the low intensity pulses (or zero level noise) enter the HNLF, the spectrum broadening is small and it does not pass through the pass band of OBPF. When the high intensity pulses (or one level noise) enter the HNLF, the spectrum broadening is large enough to extend over the pass band of OBPF. Thus, the amplitude noise in the one and zero level can be suppressed by means of optical filtering.

IV. SYSTEM DESIGN

Fig.3 shows Simulation Layout of all optical 2R regenerator based on self phase modulation All optical signal regenerator based on SPM consists of a transmitter, signal transmission stage, signal regeneration stage and receiver. Transmitter consists of a pseudo random generator, guassian pulse generator, continuous wave laser and Mach-Zehnder amplitude modulator. The CW laser and 10Gbps RZ Pseudo Random Bit Sequence signal is modulated by Mach-Zehnder Modulator and then is sent to the transmission span. In the bit sequence, each 1 bit contains a Gaussian pulse with a full-width at half maximum of 33ps (typical pulse width for 10Gbps signal) at a carrier wavelength of 1550nm. The fiber is of 50km-long single mode fiber (SMF) with an anomalous dispersion of 16ps/nm/km, a dispersion slope of 0.08 ps/nm2/km, a nonlinear coefficient of 1.3W-1km-1, and attenuation of 0.2 dB/km. Total loss is recovered by EDFA with 20dB gain.

Dispersion is compensated by using dispersion compensating fiber with a length of 10km, a normal dispersion of -80ps/nm/km, a dispersion slope of 0.5ps/nm2/km , a nonlinear coefficient of 5.2W-1km-1, and an attenuation is 0.6dB/km. To recover the fiber loss, EDFA with 12dB gain is used. Both amplifiers have noise figure of 4dB.These two amplifiers are followed by OBPF with a spectral width of 500GHz to remove ASE noise added by amplifiers.

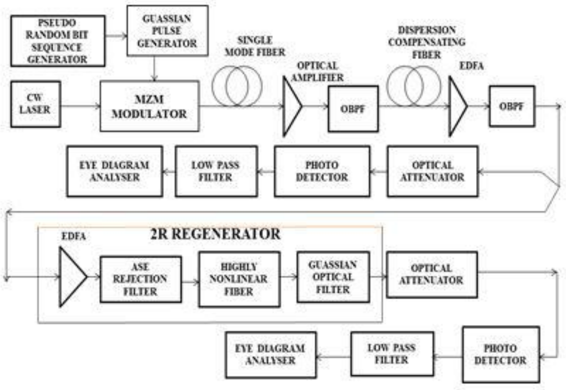

Fig.2. Block diagram to analyse the effect of all optical regenerator based on self phase modulation

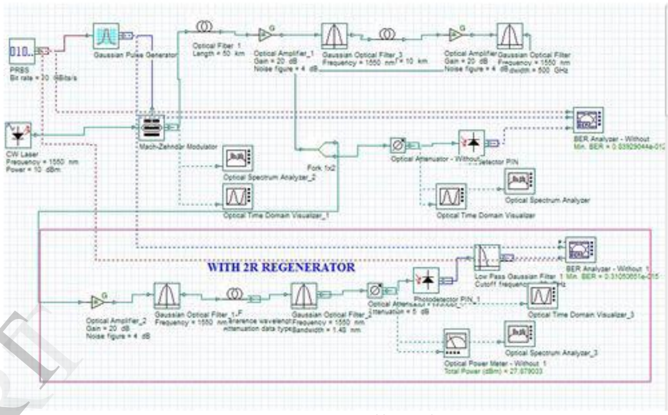

Fig.3. Simulation Layout to analyse the effect of all optical regenerator based on self phase modulation

The 2R regenerator is simulated by using a 1.007km long highly nonlinear fibre with a dispersion D of -7.2ps/nm/km, a nonlinear coefficient of 12.6W-1 km-1,and attenuation of 0.47dB/km. It contains a high power EDFA with a noise figure (NF) of 4dB. The ASE rejection filter with a Gaussian shape has a spectral width of 75GHz.

V. RESULTS AND DISCUSSIONS

Fig.4.shows shows the spectrum of input signal at a bit rate of 10Gb/s at an input power of 10dBm.After the signal passing through a single mode fiber of length 50Km,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 due to SPM effect in HNLF signal became broadenened and is shown in Fig.5.(b) and and OBPF reshape the signal and the regenerated signal is shown in Fig.5(c).

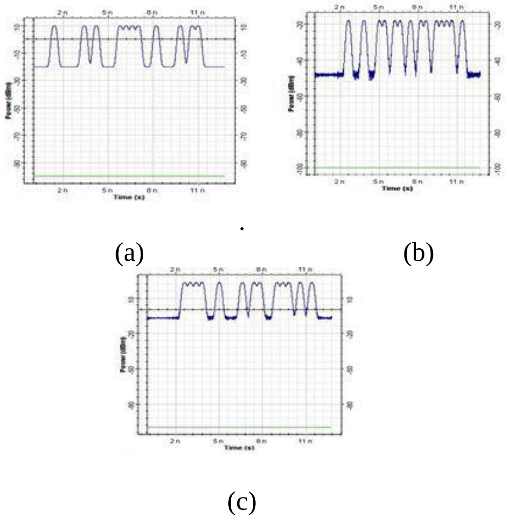

Fig.4. (a) input signal (b) degraded signal(c)regenerated signal

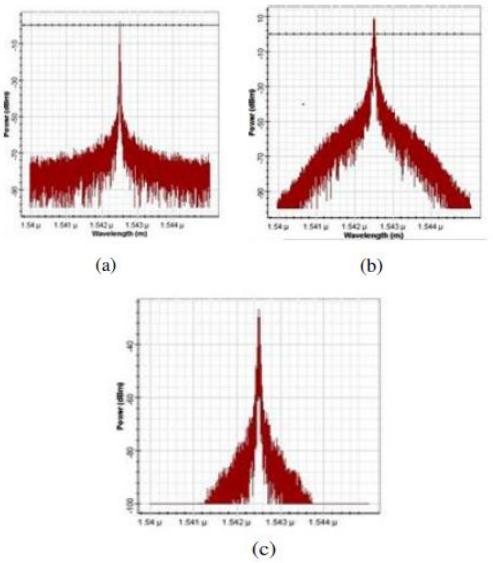

Fig.5. (a) input signal (b) degraded signal(c)regenerated signal

Fig.6.(a) shows degraded eye diagram after the signal propagating in 50Kmfiber. The degraded signal having a Q factor of 6.54 .Eye diagram of the signal regenerated by 2R is shown in Fig.6.(b).It shows that more eye opening can be seen in eye diagram of 2R and Q factor increases as compared to degraded signal.

Fig.7 shows the power transfer function curves of all optical 2R regenerator based on SPM. At low power,zero level noiseis suppressed and a constant output power occurs upto a fixed threshold.The threshold value is different for different regenerators.As input power increases above the threshold value,a constant output power is obtained which shows the suppression of one level noise.The flat top region shows the performance of regenerator.Thus zero level and one level noise is suppressed by 2R regenerator.

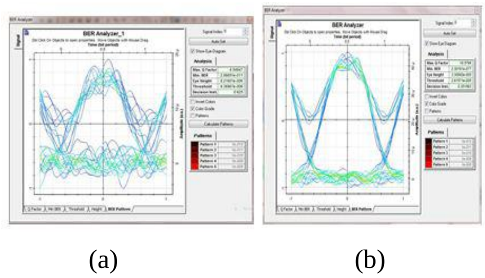

Fig.. 6 (a)Degraded eye diagram at 10Gb/s (b) eye diagram with 2R regenerator at 10Gb/s

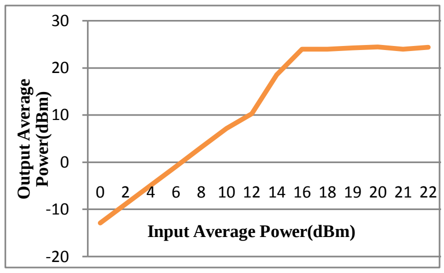

Fig..7. Power transfer function curves of all optical 2R regenerator based on SPM

VI.CONCLUSION

All –optical 2R regenerator based on self phase modulation is implemented .Analysis is done using eye diagram and power transfer function.All-optical 2R regenerators based on SPM have improved Q factor of around 18 and is efficient for single wavelength operation.

ACKNOWLEDGMENT

The author is deeply thankful to her teachers,Department of Electronic and Communication Engineering,TKM Institute of Technology,Kollam

REFERENCES

1. Soe Soe Hnaung ,"Design and Implementation of 10Gbps All-Optical 2R Regenerator" International Journal of Computational Engineering and Management(IJCEM),Volume. 17 Issue 3, May 2014.
2. Gopal, Jimmy Gautam, Ayushi Barthwal "40 Gbit/S All-Optical Signal Regeneration with Soa In Mach-Zehnder Configuration" IOSR Journal of Electronics and Communication Engineering & (IOSR-JECE),Volume 6, Issue 2 (May. - Jun. 2013),PP 33-35.
3. E.A.M.Fagotto,U.R.C.de Miranda," Design of Four Wave Mixing frequency shift free amplitude regenerators", Journal of Microwaves,OptoelectronicsandElectromagneticApplications,Vol.no .12,No.1,2013.1989.
4. Govind .P Agrawal"Applications of Nonlinear Optics"Elsevier Publications,Second edition,2009.
5. Prashant P.Baveja,DrewN.Maywar ,"Optimization of all optical 2R regenerators Operating at 40Gb/s:Role of dispersion "Journal of light wave technology,Vol.27.No.17,Sept1,2008.