Enhancement in performance of 15Gbps Receiver using Single pump Raman Amplifier

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ABSTRACT: *Optical amplifiers are the key elements of any fiber communication System. This paper describes the improvement in performance of the receiver by using the Raman amplifier. Analysis of 15Gbps PIN receiver is carried out and various parameters like Q factor, BER, Received optical power can be obtained using the optsim 5.0 simulation software.The relation between the length and BER at different pump power, Q and length at different pump power is carried out.*

Keywords— Raman scattering, Raman amplifier, Optical receiver

I: INTRODUCTION

Optical Fiber Communication Systems are being extensively used all over the world for telecommunication, Video and data transmission purpose. In Fiber optic communication, there is a degradation of transmission signal with increased distance. By the use of optoelectronic repeater, this loss limitation can be overcome. In optoelectronic repeater, optical signal is first converted in to electrical signal and then after amplification it is regenerated by transmitter. But such regeneration becomes quiet complex and expensive for wavelength division multiplexing system. So to remove loss limitation, optical amplifiers are used which is directly amplify transmitted optical signal without converting into electrical form. Nonlinear effects within optical fiber provide optical amplification, this is achieved by stimulated Raman scattering, stimulated Brillion scattering or stimulated four photon mixing by injecting a high power laser beam into undoped or doped optical fiber. Raman amplification exhibits advantage of self phase matching between the pump and signal together with a broad gain- bandwidth or high speed response in comparison with the other nonlinear Processes. There are two types of Raman amplifier discrete (lumped) and distributed Raman amplifier. Distributed type Raman amplifier (DRA) utilizing transmission optical fiber as an active medium if the amplifier is contained in a box at the transmitter or receiver end of the system it is called a discrete Raman amplifier.
Raman scattering is a nonlinear effect. For high enough pump powers, the scattered light can grow rapidly with most of the pump energy converted into scattered light. This process is called SRS. There are three important points-(1) SRS can occur in any Fiber (2) Raman gain can occur at any signal wavelength by proper choice of the pump wavelength (3) Raman gain process is very fast. The light incident on a medium is converted to lower frequency. A pump photon v_p excites a molecule up to a virtual level. The Molecule quickly decays to a lower energy level emitting a signal photon v_s in the process. The difference in energy between the pump and signal photons is dissipated by the molecular vibrations. These vibrational levels determine the frequency shift and shape of the Raman gain curve.

II. LITERATURE REVIEW

Raman amplifiers were used to improve the performance of wavelength-division-multiplexed light wave systems. The use of Raman amplification had become quite common for long-haul systems designed to operate over thousands of kilometers. The most important feature of fiber Raman amplifier is the stimulated Raman scattering, which is essentially based on Raman Effect discovered by C.V. Raman.
Arwa H. Beshr1, Moustafa H. Aly and A.K. AboulSeoud discussed the Different pump configuration for Discrete Raman Amplifier. There are three pumping schemes:

i. Co-pumping, or Forward-pumping, where both signal and pump are propagating in the same direction.
ii. Counter-pumping or Backward-pumping, where signal and pump are propagating in opposite directions.
iii. The bidirectional pumping which includes both the co-pumping and counter-Pumping, simultaneously.

The net gain of discrete Raman amplifiers as a function of different fiber length which gives the highest and lowest gain. The maximum Raman gain which equal 10^{2} dB when counter pumping and minimum Raman gain which equal 10^{-2} dB when Co-pumping. The lower gain in case of forward pumping, a higher gain in backward pumping and a medium gain in bidirectional pumping [1].

Mohsen Katebi Jahromi and Farzin Emami simulate the Distributed Raman amplifiers in different transmission media such as Z fiber and Dispersion shifted fiber (DCF). DSFs have proper noise figure level and more uniform signal gain relative to the Zfibers. These amplifiers also have the unique characteristic of being tunable at any wavelength, simply by changing the pump frequency, since gain depends only on the signal-pump frequency shift. Due to these reasons, Raman amplifiers are widely used in the fiber optical communication systems [2].

G.S. Felinskyi1, P.A. Korotkov2 proposed optical fiber Raman amplifiers with the multiwavelength pumping scheme. It is based on the oscillator theory and spectroscopic model for the analysis of the Raman gain spectrum. They analyze the fiber Raman amplifier with combined multiwavelength pumping source for the extension of amplification bandwidth to L-band, which has the broad bandwidth over 80 nm and low gain ripple less than 0.5 dB. The multiple-wave pumping enables to expand the gain bandwidths to the theoretical limit of approximately up to 12 THz [3].

S.M. Kobtsev and A. A. Pustovskikh propose the design of 100-km flat-gain backward-pumped Raman amplifier with four broadlinewidth 14XX-nm pumps with less than 0.2-dB gain-ripple in 1528–1584 nm bandwidths. By a proper choice of the pump powers and wavelengths it is possible to reduce the gain-ripple of the corresponding Raman gain contour in a broad wavelength range. The best gain flatness of Raman amplification in the C- plus L-band that has been achieved with WDM pumping technique is on the order of 0.1 dB, depending on the average gain level [4].

Toshiyuki Tokura, Taichi Kogure, Takashi Sugihara, Katsuhiro Shimizu, Takashi Mizuochi, and Kuniaki Motoshima discussed efficient pump depolarizer analysis of Distributed Raman amplifier for low PDG. Reducing DRA's PDG is important for a Raman amplifier because it can degrade transmission performance. Raman PDG is determined primarily by two factors, (1) polarization-mode dispersion (PMD) of the transmission fiber and (2) degree of polarization (DOP) of the pump source [5].

Catherine Martinelli, Laurence Lorcy, Anne Durécu-Legrand, Dominique Mongardien, and Sophie Borne discussed Influence of Polarization on Pump-Signal RIN Transfer and Cross Phase Modulation in Co pumped Raman Amplifiers. They propose a model of pump-to-signal RIN transfer that includes polarization and nonlinear gain [6].

Junhua Ji, Christophe A. Codemard, and Johan Nilsson discussed the analysis of spectral bend loss filtering in a cladding pumped W type Fiber Raman Amplifier. Cladding-pumped (CP) fiber Raman devices will potentially become an alternative to conventional rare-earth (RE) doped CP fiber devices and can be used for brightness enhancement and beam clean-up as well. W-type cores have been used in CP RE-doped fiber devices to suppress unwanted long-wavelength emission, including SRS [7].

Kulwinder Singh, Manjeet Singh Patterh, Manjit Singh Bhamrah proposed the effect of counter propagating pumping in fiber Raman amplifier. By increasing the number of counter propagating pumps the gain bandwidth increases regularly and it makes amplifiers more flat [8].

David Menashe, Dominique Bayart, Sophie Borne proposed a lumped Raman amplifier for all-Raman long-haul and ultra-long haul optical communications systems based on highly non-linear Photonic Crystal Fiber (HNL-PCF),and analyzed the specifications such as Noise Figure, Multi-Path Interference (MPI), and transient suppression. The HNL-PCF should exhibit high Raman efficiency and low attenuation at pump wavelengths of 1470-1500nm, resulting in a Figure of Merit (FOM) above 8 dB-1W-1 [9].

Shao Hao Wang, Lixin Xu, P. K. A. Wai, Hwa Yaw Tam investigated relationship between the overall gain and different combinations of Raman and parametric pump powers using contour maps. They derived a normalized phase-matched model to determine the general behavior the peak gains of RA-FOPAs operating in the small signal region. They shown that it is possible to optimize the Raman and parametric pump powers in RA-FOPAs for high gain and high efficiency [10].

III. SIMULATION MODEL

Table 3.1Parameters for PIN receiver and Raman amplifier

Pump power	0.5watt
length	50km
Dark current (I_P)	1 X 10^{-6} amp
Transmitter wavelength	1550e-9
Pump wavelength	1450e-9
Average rec power	-25
Filter Bandwidth	9.5 GHz
Filter order	4
Min BER	10^{-9}

(A)PIN receiver with Raman amplifier

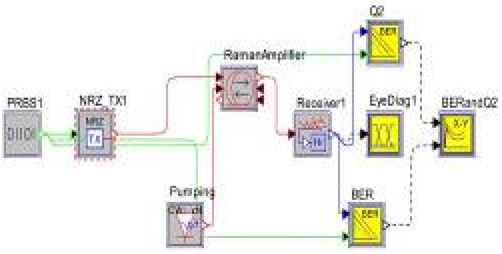

Fig.1Single pump Raman amplifier at PIN receiver

IV.SIMULATION RESULTS AND DISCUSSION

PIN receiver using Raman amplifier

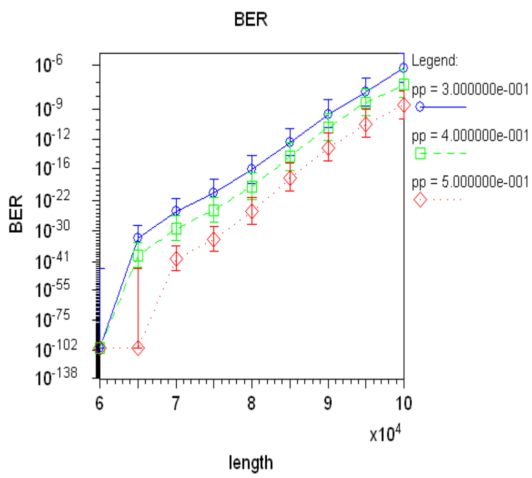

Fig.(a) BER vs length

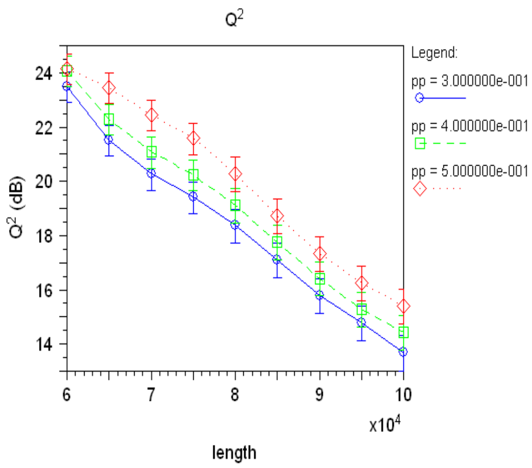

Fig.(c) Q factor vs length

(B)PIN receiver without Raman amplifier

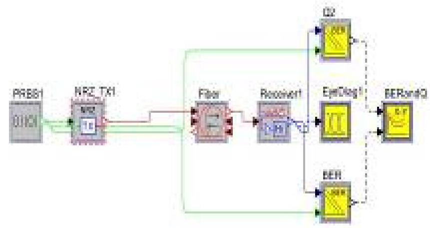

Fig.2PIN receiver without Raman amplifier

PIN receiver without Raman amplifier

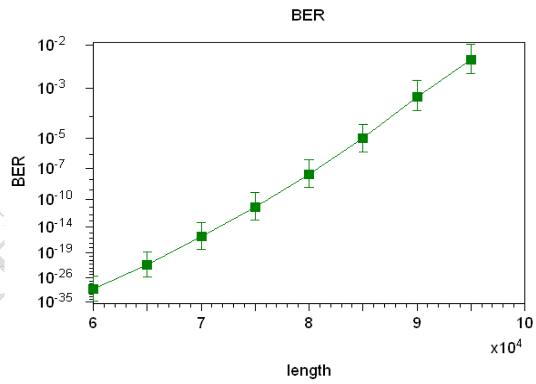

Fig.(b)BER vs length

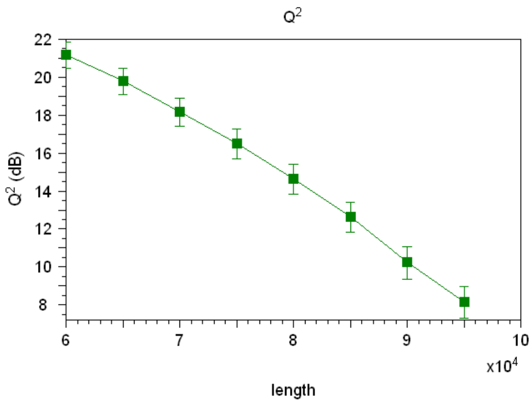

Fig.(d)Q factor vs length

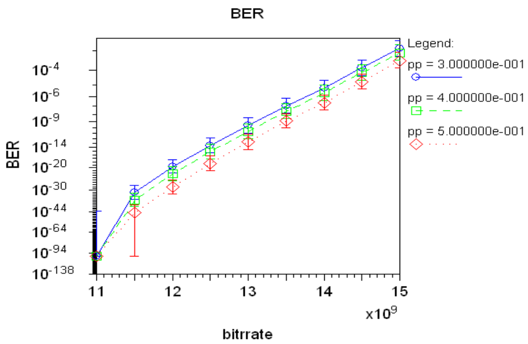

Fig.(e) BER vs bitrate

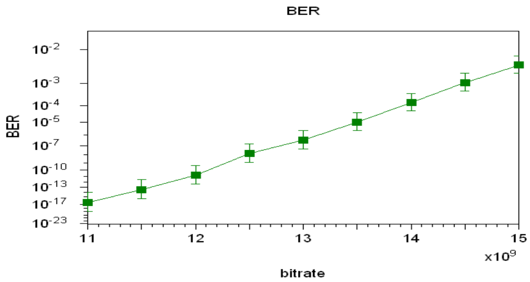

Fig.(f) BER vs bitrate

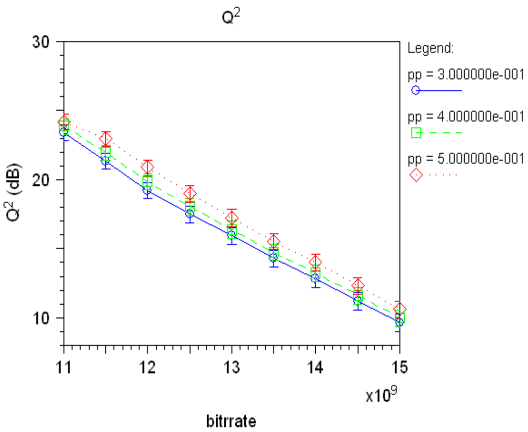

Fig.(g) Q factor vs bitrate

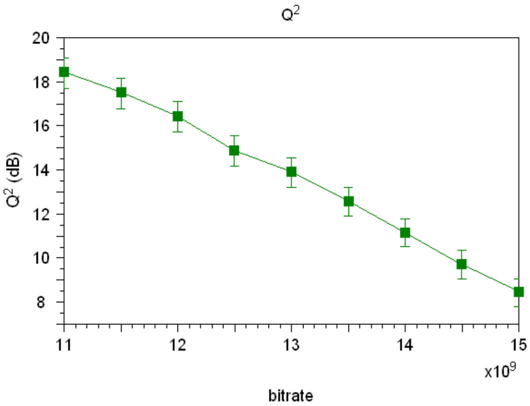

Fig.(h) Q factor vs bitrate

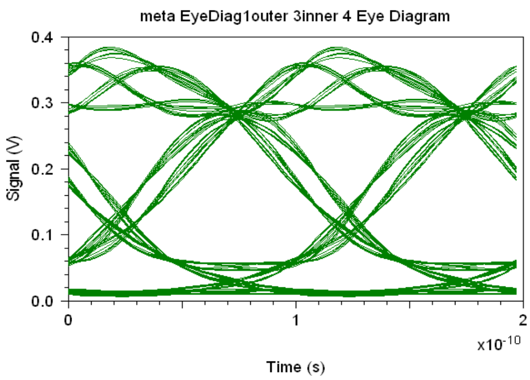

Fig.(i)Eye diagram

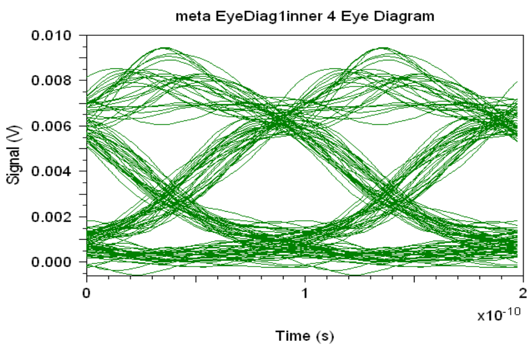

Fig.(j) Eye diagram

The relation between BER and length, Q factor and length, Q factor and bitrates, BER and bitrates is carried out using the optsim 5.0 software. It is observed that PIN receiver gives better performance by using the Raman amplifier than without using that. Figure (a) and (b) shows how the BER increases as the length of fiber increases.

Figure (a) shows that the BER increases higher at the lower pump power as the length increases.At higher pump power the BER increases less.Figure(b) shows that BER increases more as the length increases in PIN receiver without using raman amplifier.
Figure (c) and (d) shows the relation between the Quality factor and length of the fiber.The Q factor value is better in figure(c) than in figure(d).

As the length of the fiber increases the Quality factor decreases.
Figure(e) and (f) shows the relation between BER and bitrate at 15Gb/s.At the higher bitrates the BER increases more in figure(f)as compared to the figure(e).
Figure (g) and (h) shows that how the Quality factor decreases as the bitrate increases.Figure(i) and (j) Eye diagram.In Figure(i) shows that the opening ,height,and width is good than the figure(j).

V.CONCLUSION

Comparision of the PIN receiver at 15 Gb/s by using the Raman amplifier and without using the Raman amplifier is carried out**.** From the above results it is clear that Raman amplifier improves the performance of the PIN receiver at 15Gb/s which can be proved by measuring the parameters like BER,Qulity factor,Eye diagram.PIN reciver using Raman amplifier gives the less increases in BER as the function of the fiber length. The Quality factor reduced less as the length increases.

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