Analysis of Confinement Factor in SOA for Optical Communication System

Aruna Rani[1] and Sanjeev Dewra[2]
[1,2]*Department of Electronics and Communication Engineering,*
Shaheed Bhagat Singh State Technical Campus, Ferozepur, Punjab, India
E-mail: [1]arunarani70@gmail.com, [2]sanjeev_dewra@yahoo.com

***Abstract*—The 32 channel optical system based on optimized Semiconductor optical amplifier at 10 Gb/s have been investigated in this paper, and the performance of optical system has been analyzed by varying the confinement factor of SOA. The communication over fiber optical link is evaluated upto 245km transmission distance for 0.4 confinement factor of SOA at low input signal power of -40 dBm. It is also evaluated that the signal can be effectively transmitted with acceptable quality of signal and BER upto 157, 201 km for 0.2 & 0.3 confinement factors respectively.**

Keywords: Semiconductor Optical Amplifier, Dense Wavelength Division Multiplexing System, Quality Factor, Bit Error Rate

I. Introduction

A semiconductor optical amplifier (SOA) will be the best aspirant for the optical amplifier considering its compact size, flat-gain, cost-effectiveness, and low-power consumption [1–3]. The use of SOA as multifunctional device allows performing all optical functions based on its nonlinearities [4, 5]. To meet the requirement SOAs are promising because of their compactness and simple current pumping. The gain in a SOA saturates as the optical power level increases [6]. Singh *et al.* [7] presented the placement of semiconductor optical amplifier for 10Gbps non-return to zero format in dispersion–compensated fiber and single mode fiber link. In this work, different pre, post and symmetrical compensation methods for different locations of the SOA in fiber link have been reported. The impact of increase in signal input power for these three power compensation methods are compared in terms of BER, eye closure penalty and output received power. It was observed that the post power compensation method is better to symmetrical and pre power compensation methods when SOA is used. Woosuk Choi [8] analyzed the performance of 8 × 10 Gb/s transmission over 240 km wavelength division multiplexing system caused by crosstalk in cascaded conventional semiconductor optical amplifiers. Sun *et al.* [9] investigated an error-free transmission 32 × 2.5 Gb/s DWDM channels over 125 km using cascaded in-line SOAs. Kim et al. [10] successfully transmitted 10Gb/s optical signals over 80km through SSMF using SOAs as booster amplifiers. They have further found the suitable parameters of input signals for SOAs, such as rising/falling time, extinction ratio and chirp parameter to maximize output dynamic range and maximum output power.

In this paper, we extended the previous work by increasing the number of channels and transmission distance without any power compensation methods by using DS-Normal fiber only and investigated the performance of SOA for dense wavelength division multiplexed system by varying the confinement factor.

This paper is structured as follows. Section I presents introduction. Section II discusses the schematic setup of DWDM system using SOA. In Section III, results of SOA by varying confinement factor are presented and Section IV gives a brief outlook for the conclusion.

II. System Setup

Figure 1 is a system setup of an optical transmission system using semiconductor optical amplifier. The system consists of 32 channels whose wavelengths ranged from 192.35 THz-193.85 THz with a spacing of 100 GHz. Each transmitter consists of data source, laser source, NRZ rectangular driver, and optical amplitude modulator. Data source generates a pseudorandom binary sequence of data stream. The data is converted into optical signal using continuous wave lorentzian (CW) laser source Data format of the type NRZ rectangular is generated by the modulation driver. The pulses are modulated using Sin2 Mach-Zehnder modulator at 10 Gbps. The combined signals with an optical combiner were modulated simultaneously at 10 Gb/s. The signal was then input to DS-Normal fiber of the reference frequency 192.35 THz, dispersion-2ps/nm/km and attenuation is 0.2 dB/km. Then the output is fed to semiconductor optical amplifier through an optical splitter. The optimized parameters of SOA used in the simulation are as follows: bias current is 290mA, the length is 400 mm, the width of the active layer is 2 mm, and its thickness is 0.2 mm. The transparency carrier density in the SOA is taken to be 1.5×1018cm^3, Spontaneous Carrier lifetime is 0.3 ns and the differential gain 3 × 10-16 cm^2. The input and output coupling losses of SOAs are taken as 3 dB. The optical splitter (S1) is used to measure the optical input power for the transmission link. Optical Power meter and Optical probe with splitter (S2) are used for the measurement of optical signal power and spectrum at different levels.

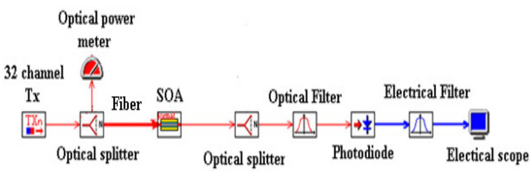

Fig. 1 System Setup based on Semiconductor Optical Amplifier

A single receiver consists of PIN photodiode, optical and electrical raised cosine filter. Optical filter component composed of a raised cosine transfer function filter having 1 as raised cosine exponent, 0.2 raised cosine roll off, 193.15 THz center frequency and band pass filter synthesis. the optical signal is converted into electrical signal using PIN photodiode. The PIN detector having responsivity of 0.87 and quantum efficiency 0.7 A/W. Electrical filter at the receiver side is raised cosine filter and has bandwidth of 8GHz. Electrical scope is used to attain the eye diagram. From the eye diagram, the values of Quality factor, BER and Eye closure can be analyzed.

III. Results & Discussion

The semiconductor optical amplifier has been investigated for 320 Gbps DWDM system in the term of quality of signal, bit error rate, eye closure and output power at channel-1. The Q factor vs. transmission distance at different confinement factors is as shown in Fig. 2. For 0.4 confinement factor, maximum transmission distance 245 km is covered and at 0.1 confinement factor, acceptable Q factor is obtained upto 105 km distance at -40 dBm signal input power. It is evident that the quality of the signal decreases with increasing the length of the fiber at low confinement factor. Our results are in coincidence with our previous results [5, 7] where we analyzed the performance of WDM system based on SOA with the same bit rate and channel spacing. Fig.3 indicates the bit error rate vs. transmission distance at different confinement factors. At 0.1 confinement factor, acceptable bit error rate (10–9) is achieved up to 105km. For 0.2 & 0.3 confinement factor, transmission distance increases up to 157 km & 201 km respectively. The transmission upto 245 km is achieved with acceptable bit error rate at 0.4 confinement factor. Fig.4 depicts the eye closure vs. transmission distance for different confinement factors at-40 dBm signal input power. We observed that 0.4 confinement factor provides least eye closure 2.13 dBm at 245 km distance. Means as we increase the transmission distance, the eye closure goes on increasing. As the eye closure increases, the quality goes on decreasing.

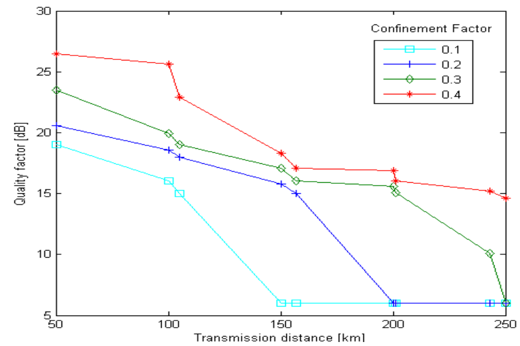

Fig. 2 Quality Factor vs. Transmission Distance for different Confinement Factors at -40 dBm Signal Input Power

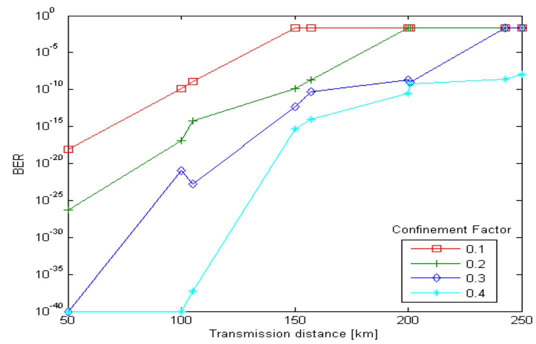

Fig. 3 BER vs. Transmission Distance for different confinement Factors at -40 dBm Signal Input Power

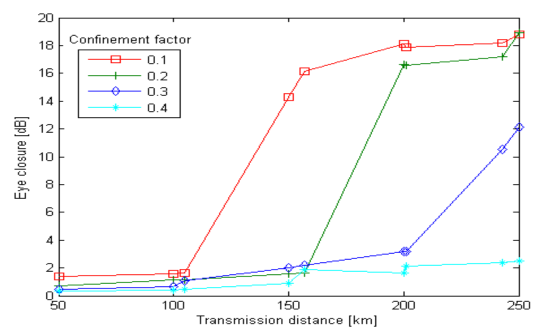

Fig. 4 Eye Closure vs. Transmission Distance for different Confinement Factors at -40 dBm Signal Input Power

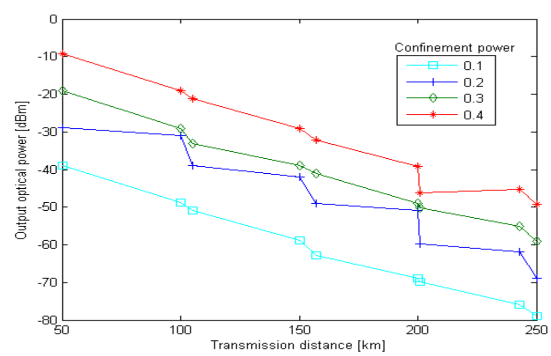

Fig. 5 Output Optical Power vs. Transmission Distance for different Confinement Factors at -40 dBm Signal Input Power

Figure 5 depicts the received signal power vs. transmission distance for different confinement factors. For 0.4 confinement factor upto 245 km transmission distance -46.16 dBm output power with the signal input power of -40 dBm is obtained.

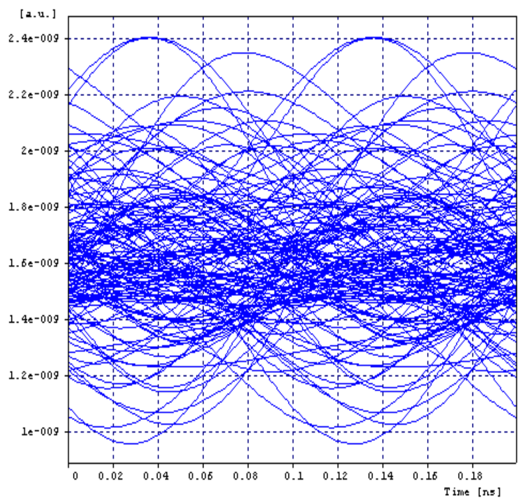

Fig. 6 Eye Diagram at 0.1 Confinement Factor for 215km Transmission Distance

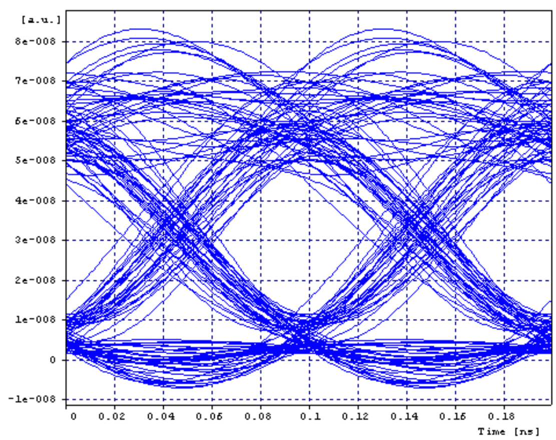

Fig. 7 Eye Diagram at 0.4 Confinement Factor for 215km Transmission Distance

The eye diagrams for 0.1 & 0.4 confinement factors are shown in Fig. 6 & 7. At low confinement factor of 0.1, acceptable BER and quality factor is obtained upto 105 km transmission distance. At low value of confinement factor the output signal is degraded. By increasing the confinement factor, large transmission distance is achieved. The 215km transmission distance is covered successfully for 0.4 confinement factor.

IV. Conclusion

In this paper, we have analyzed the performance of the 32 channel DWDM system based on optimized SOA at 10 Gbps with 0.8 nm channel spacing. The results have been reported for different confinement factors. We have observed that the signal can be transmitted successfully with improved performance upto 245 km transmission distance for 0.4 confinement factor of SOA at low input signal power of -40 dBm. For low confinement factor of 0.1, only 105km transmission distance is covered. In addition, it is found that the system provides acceptable performance up to 157 km & 201 km for confinement factors of 0.2 and 0.3. It is evident that the quality of the signal decreases at low confinement factors.

Acknowledgment

The authors would like to thank the Rsoft design group for the OptSim simulation software for optical communications systems.

References

[1] Y. Sun, A. K. Srivastava, S. Banerjee, J. W. Sulhoff, R. Pan, K. Kantor, R. M. Jopson, and A. R. Chraplyvy, “Error-free transmission of 32×2.5 Gbit/s DWDM channels over 125 km using cascaded in-line semiconductor optical amplifiers,” Electron. Lett., vol. 35, pp. 1863–1865, 1999.

[2] L. H. Spiekman, J. M. Wiesenfeld, A. H. Gnauck, and L. D. Garret, “Transmission of 8 DWDM channels at 20 Gb/s over 160 km of standard fiber using a cascade of semiconductor optical amplifiers,” IEEE Photon. Technol. Lett., vol. 12, pp. 717–719, June 2000.

[3] H. K. Kim, S. Chandrasekhar, A. Srivastava, C. A. Burrus, and L. Buhl, “10 Gbit/s based WDM signal transmission over 500 km of NZDSF using semiconductor optical amplifier as the in-line amplifier,” Electron. Lett., vol. 37, pp. 185–187, 2001.

[4] Christian Bohémond, Thierry Ramp one, and Ammar Sharaiha, “Performances of Photonic Microwave Mixer Based on Cross-Gain Modulation in a Semiconductor Optical Amplifier” Journal of Light wave Technology, vol. 29, no.16, pp. 2402-2409, August 15, 2011.

[5] Aruna Rani, Mr. Sanjeev Dewra, “Performance evaluation of DWDM system using Semiconductor optical amplifier in the presence of fiber non-linearities”, International Journal of Enhanced Research in Science Technology & Engineering, vol. 3 Issue 2, pp.301-305, February-2014.

[6] Bobby Barua, “Evaluate the Performance of Optical Time Division Demultiplexing with the Gain Saturation effect of Semiconductor Optical Amplifier” IACSIT International Journal of Engineering and Technology, Vol. 3, No. 5, October 2011

[7] Surinder Singh, R.S. Kaler “Placement of optimized semiconductor optical amplifier in Fiber optical communication systems” Optik, vol.119, pp.296–302, 2008.

[8] W. Choi, S. Hur, J. Lee, Y. Kim, J. Jeong, Transmission performance analysis of 8×10 Gb/s WDM signals using cascaded SOAs due to signal wavelength displacement, J. Lightwave Technol., vol. 20, pp. 1350–1356, 2002.

[9] Y. Sun, A.K. Srivastava, S. Banerjee, J.W. Sulhoff, Error free transmission of 32×2.5 Gbit/s DWDM channels over 125km using cascaded inline semiconductor optical amplifiers, Electron. Lett., vol. 35, pp.1863–1865, 1999.

[10] Y. Kim, H. Jang, Y. Kim, J. Lee, D. Jang, J. Jeong “Transmission performance of 10Gb/s 1550-nm transmitters using semiconductor optical amplifiers as booster amplifiers” IEE Journal of Lightwave Technology, Vol. 21, No.2, pp.476–481, 2003.