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Performance Analysis of Semiconductor Optical Amplifier as Pre amplifier in 16 Channel Nrz Optical Transmission System.

Neetu Singh[a], Kulwinder Singh[b]

[a] MTech student ECE UCoE, Punjabi University, Patiala India

[b]Associate Professor ECE UCoE, Punjabi University, Patiala India

Abstract

In this paper, 16 channels WDM system at 10 Gb/s have been investigated for the semiconductor optical amplifier as pre amplifier and performance has been compared on the basis of optical fiber length and confinement factor of SOA with nonlinearities. It is demonstrated that when injection current 0.19 A, SOA provides better results because as we increase in injection current, the gain saturation problem arise due to cross gain modulation and four wave mixing. At confinement factor 0.34, and launched power -20 dBm, SOA provides better results in terms of BER and output power, as we increase the confinement factor the BER of the system deteriorated.

Keywords:*bit error rate, Confinement factor, launched power,semiconductor optical amplifier*

1. Introduction

The advancement in multi-channel optical

communication system has come with the development of powerful optical amplifier. Optical amplifiers are directly amplifying the optical signal without any conversion in electrical domain.

Semiconductor optical amplifier is useful device for optical fibre transmission systems as compared to fiber amplifier, due to their low cost, small size, low power consumption, ultra-wide band gain

spectrum, ease of integration with other devices. These amplifiers are pumped electrically.

In optical communication, when optical receiver detect the optical signal it also generates the thermal noise, shot noise etc and crossponding bit error rate of received signal is get increased. Semiconductor optical amplifier is used as a pre amplifier to improve the sensitivity of the optical receiver.

Surinder singh, [1] optimized SOA parameters to minimize the gain fluctuations. He evaluated the performance of the preamplifier system on single and 20 channels with 100 Ghz spacing. It was found that 0.25ns is the optimum value of carrier lifetime to be used.

T.Yamatoya, [2] used the SOA as a optical preamplifier at 3 dB bandwidth of SOA, and SOA bias current was 400 mA used at 10 Gb/s bit rate and he achieved the optical receiver sensitivity of -22.7 dBm.

Shuangmei Xu, [3] analysed that increasing carrier lifetime while reducing the diffenatial gain reduces the crosstalk in SOAs and obtained a BER of 10^{-9} at a received power of -15 dBm while using SOA as a pre amplifier. It has been shown that crosstalk is function of confinement factor, and bias current.

SurinderSingh. [4] investigated the performance in 20 channels at 10 Gb/s WDM transmission over 43 40 km using SOA as in-line and pre-amplifier. In this work it has been shown that saturation ofSOA strongly depends on confinement factor..

We have investigated the SOA as pre amplifier in terms of structure parameters for improvement in receiver sensitivity for PIN receiver at 10 Gb/s. This paper is arranged into four sections. In section 2, theoretical analysis has been presented for SOA preamplifier. In section 3, SOA Systemsetup reported and In section 4 system description presented In section 5, SOA structure parameters are reported, and finally in section 6, conclusions are made.

2.Theoretical analysis

In the analysis of semiconductor amplifiers, we usually calculate the mode gain based on the optical confinement factor that is determined by standard definition. The optical confinement factor Γ of SOA ,which is usually defined as the proportion of the square of the electric field in the active region was also used in the analysis of vertical cavity surface-emitting semiconductor lasers, [5] .

$$\Gamma = \frac{d}{L_{\text{eff}}}\left(1 + \frac{\sin k_a d}{k_a d}\right), \quad (1)$$

Where $k_a$is propagation constant in active region and L_{eff} is the sum of the length of the cavity and the phase penetration lengths of the distributed Bragg reflectors, and d is thickness of the active layer.

Confinement factor analysis of SOA, For TE modes

$$\Gamma_{\text{TE}} = -\frac{2\beta_i}{g_0} = \frac{\int_{\text{active}} n_r |E_y(x)|^2 dx}{N_m \int_{-\infty}^{\infty} |E_y(x)|^2 dx}. \quad (2)$$

Where $\beta_i$is the complex propagation constant, and represents the scalar components of electric and magnetic fields in the Cartesian coordinate system. g_o is mode gain of active area.

We consider the multi-channel WDM case, the rate equations that governsthe small signal gain g_o is given by [6]

$$g_o = \left(\Gamma\sigma_g / V\right)(I\tau / q - N_t) \quad (3)$$

Where Γ is confinement factor, $\sigma_g$is differential gain, V is active value, I is bias current, τ is carrier lifetime, q is charge of electron and Nt is the transparency carrier density.

Gain coefficient of the amplifier is given by

$$g(t,z) = [N(t,z) - N_t]a\Gamma L \quad (4)$$

where L is the length of active region of SOA. Crosstalk can be suppress by keeping the gain coefficient constant.

4. System Descrption

The schematic of system setup is shown in fig. 1. The 16 channels WDM system has been operated at 10 Gb/s in the frequency range of 193.1-194.2 THz with 100 GHz channel spacing. WDM transmitter consists of pseudo random bit sequence generator, NRZ pulse generator, Directly modulated CW laser. The CW laser is set to launched at – 20 dBm power in each channel.

The total length of fiber link was 245 km made of seven spans. Each span was made of one single mode fiber (SMF) of length 30 km and one Dispersion compensating fiber (DCF) of 5 km and an EDFA is used as inline amplifier. The fibernon linear effects were considered and Raman crosstalk turned off. The receiver consists of PIN photodiode, 3R Regenerator and an electrical Low pass Bessel filter.

5. SOA structure parameters

The theoretical analysis of SOA pre amplifier is analysed. The typical structural parameters of SOA as follows; [4] the cavity length of SOA is 500 µm, the width of active layer is 2 µm, its thickness is 0.2 µm. The transparency carrier density in the SOA is taken $1.4 \times 10^{-24} m^{-3}$,differential gain is 2.7×10^{-20} m^2. The typical fiber and system parameter as given in Tabel1. The input and output coupling losses of SOAs are taken as 3 dB. EDFA amplifier is used in line amplifier of gain value 5 dB and noise figure of EDFA amplifier is 4 dB

Table 1

Parameter	Value	Units
DCF attenuation	0.55	dB/km
SMF attenuation	0.2	dB/km
DCF dispersion slope	-0.48	Ps/ns/km
SMF dispersion slope	0.08	Ps/ns/km
Photodiode dark current	10	nA
Receiver responsivity	1	A/W
Low pass filter depth	100	dB
Low pass filter order	4	
Low pass filter cut off Frequency	7.5	GHz
3R Regenerator Absolute threshold	0.5	a.u
3R Regenerator reference bit rate	10	GBit/s

3. Results and discussion

We analyse the effect of cavity parameters of SOAwith transmission distance of optical fiber system, in terms of injection current.

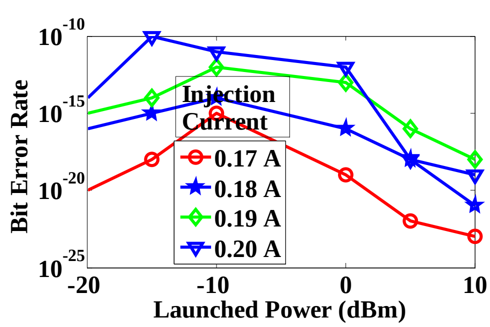


Fig. 2 Bit Error Rate varies launched power at different Injection current , of SOA preamplifier in multi-channel WDM transmission., in presence of 16 channels .

Fig. 2 shows the BER and launched power at different injection current. For small value of injection current 0.17 A, value of BER is 10^{-22}.At injection current 0.18 BER obtained is 10^{-17}. At high value of injection current i.e. 0.20 A, poor BER is obtained. It is also observed that with increases in launched power, BER is increasing at -10 dBm launched power, but furtherincrease in power, good BER is obtained, because system losses are decreasing. SOA gives better performance at 0.17 A, due to low cross gain modulation.

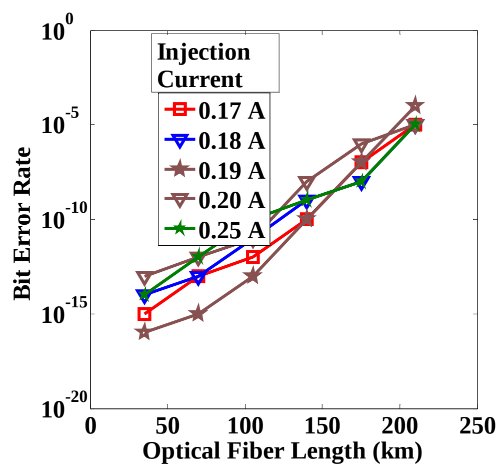


fig. 3 Bit Error Rate varies fiber length for different injection current , of SOA preamplifier in multi-channel WDM transmission, In presence of 16 channels

Fig.3, represents the graphical representation of BER as a function of optical fiber length and injection current in presence of non lineraties. It is observed that for injection current 0.19 A of SOA has low BER of the order 10^{-17} at 35 km and it increasing linearly up to 140 km. if the injection current is more than 0.20 A, then poor BER is observed. It is observed that SOA provides poor BER among all in distance range from 140 to 245 km, due to dispersion, non linearities, and receiver noise. For injection current 0.19 A SOA provides the better performance.

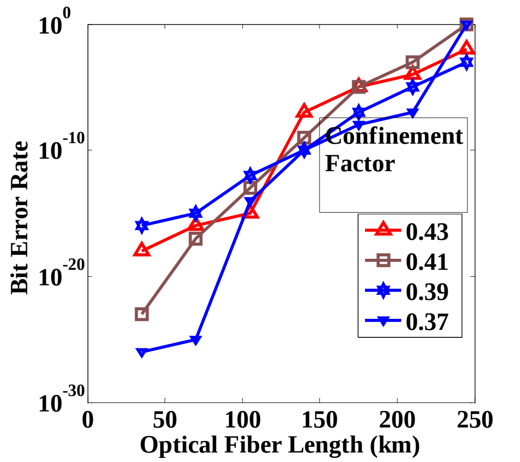


Fig. 4 Bit Error Rate varies Optical Fibre Length at different confinement factor , of SOA preamplifier in multi-channel WDM transmission.

We further analysis the effect of confinement factor of SOA preamplifier in 16 channel WDM transmission system.fig. 4 shows that,WDM system performance is degrades, as well as confinement factor of SOA is increasing.for confinement factor 0.37, 10^{-26} BER is obtained for transmission distance of 35 km. With further increase in confinement factor to 0.39, the BER starts increasing 10^{-17} to 10^{-7} for fiber length 210 km, which is not reasonable as compared to that observed in 0.37 with the same fiber length. So we observed that SOA gives better result for 0.37 confinement factor.

If the confinement factor is more than 0.39, then poor BER is observed. It is also observed that with increases in fiber length BER is also increasing.

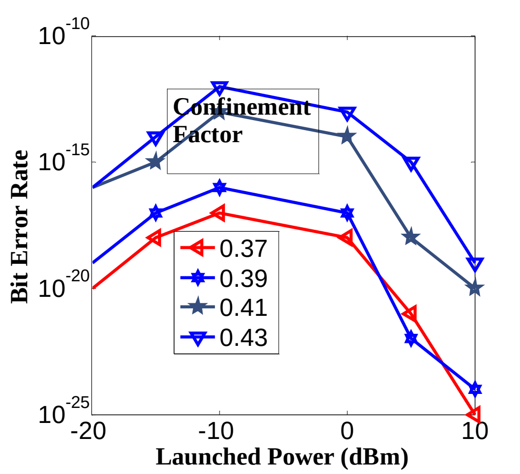


Fig. 5 Bit Error Rate varies launched power at different confinement factor, of SOA preamplifier in multi-channel WDM transmission.

Simulation are carried out for different confinement factor of an SOA as pre amplifier, which is used for transmission. The variations of BER with increase in launched power are shown in fig. 5 for different confinement factor. For confinement factor of 0.43, poorBER is obtained. But for confinement factor 0.39 low BER is obtained, which is less than 10^{-18} for -20 dBm launched power. For confinement factor 0.37, SOA provides the reasonable BER , which is less than 10^{-22} for -20 dBm input power.

As we increase the launched power the system BER deteriorates but further increase in power, BER improves because system loss and amplification works only after -10 dBm power. It has been observed that at 0 dBm to mitigate the fiber loss and dispersion penalties.

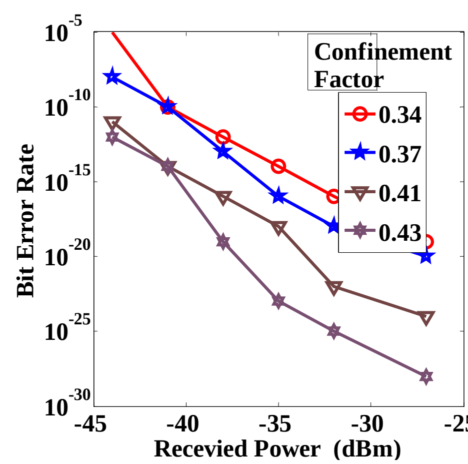


Fig. 6 Bit Error Rate varies Received power for different confinement factor, of SOA preamplifier in multi-channel WDM transmission.

The variations of bit error rate with increase in received power are shown in figure 6 for different confinement factor. For confinement factor 0.34, BER is poor. But for confinement factor 0.43, low BER is obtained, which is more than 10^{-12} for -45 dBm received power.

It is observed that BER goes on decreasing with increase in confinement factor. It is also observed that BER is also decreasing with increase in received power; due to fiber losses are met. It has been observed that 0.37 is the best confinement factor with launched power, but its value is 0.43 best for receiver power analysis. So 0.37 and 0.43 value are the better for system performance.

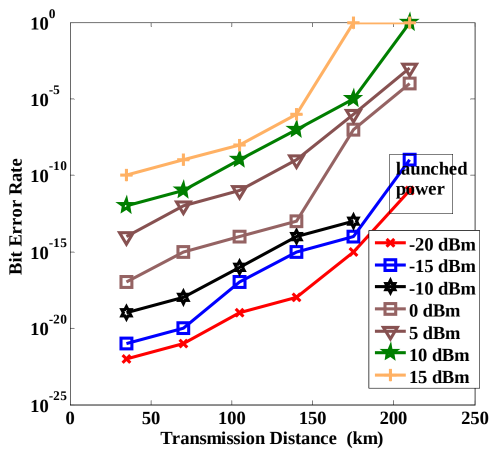
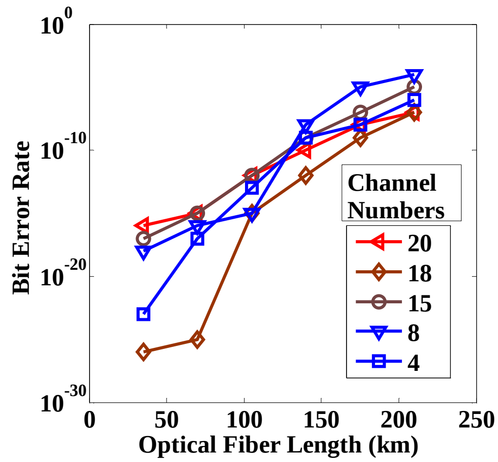


Fig 7 Bit Error Rate varies optical fiber length at different input launched power, for Confinement factor 0.34.

In figure 7, we seen that, for input power 15 dBm, at fiber length 35 km BER is 10^{-23}, at fiber length 140 kmBER is 10^{-18}. Further decrease in launched power to find the BER for different fiber length. Bit Error Rate is measured for fiber length 35, 70, 105, 140, 175, 210, 245 km as in Fig.7

For launched power 15dBm, BER is observed is good, but BER goes on increasing with increase in Fibre Length. The increase in BER is more at lower launched power for same fiber length. So that Low BER is possible by increasing the launched power.

At input power -15 dBm, 35 km BER i s 10^{-16}, and 140 km BER is 10^{--08}, In this graph we observed that at 35 km the BER is starts increase, as we furtherincreases the fiber length the nonlinearitiesand dispersion dominates the system performance.



Fig, 8 Bit Error Rate varies Fiber length for different number of channels,

fig.8 Bit error Rate of signal for all channels goes on increasing at low rate with increase in fiber length. At fiber length 35 km, approximately 10^{-28} BER is observed for different number of channels. Also for the fiber length 70 km, BER starts increasing as the number of channels is increasing to 20. but for fiber length 35 km, low BER is observed for different channels.

At fiberlength 210 km, BER is poor as compare to 35 km fiber. So we observed that with increase in fiber length, BER also increases, due to non linerties.

5. Conclusion

We have investigated the SOA, by varying optical fiber length (35-245 km) and confinement factor (0.34-0.45) in terms of BER and output power. When confinement factor 0.34, SOA provide better result but as we increase in confinement factor it degrade in performance because SOA saturation problem arises. If we take launched power 0**dBm**, and injection current 0.17 A then SOA provides better results. We also observed that at confinement factor 0.37, of SOA amplifier gives the low output power. The NRZ system performs best for 140 km fiber with bit error rate observed being less than 10^{-12} for 18channels. These results provide useful information for designing the long haul WDM transmission system

REFERENCES

[1]Surinder Singh, An approach to enhance the receiver sensitivity with SOA for optical communication systems, "*Optics Communication Elsevier",vol. 284 issue. 3*, February 2011pp 828–832,

[2] T. Yamatoya, F Kuyoma, Optical preamplifier using Optical modulation of amplified spontaneous emission in saturated semiconductor optical amplifier,*"IEEE Journallightwave technology", vol. 22, issue. 5,May* 2004, pp. 1290-95.

[3] ShuangmeiXu, Jacob B Khurgin, Igor Vurgaftman, J. Meyer, Reducing crosstalk and signal distortion in Wavelength Division Multiplexing by increasing carrier life times in Semiconductor Optical amplifiers, "*IEEE Jo urnal of Light wave technology*",*vol. 21 issue.6*,june 2003,pp.1474-1485.

[4]Surindersingh , Structural modification of semiconductor optical amplifiers for wavelength division multiplexing systems, "*Optics Communication Elsevier*"*vol. 35, issue. 1*, March 2011, pp. 2-22.

[5] Yong-Zhen Huand, Zhong Pan, Analysis of the optical confinement factor in semiconductor lasers. "*Journal of applied physics*. ,"*vol. 254, issue. 4*, April 1996 , pp.79-81.

[6] G.P. Agrawal, Fiber Optics Communication Systems, 3rd edition, Wiley publisher, Singapore, 2002, pp.234-235

[7] Vishal Sharma, Amarpal Singh , Ajay k. Sharma, Simulative investigation of the impact of EDFA and SOA over BER of a single-tone RoF system " *Optic Communication Elsevier*"*vol. 121, issue 14,* august 2010, pp. 1280-1284.

[8]N. Kikuchi, S. Sasaki, Analytical evaluation technique of self-phase modulation effect on the performance of cascaded optical amplifier systems, "*IEEE Journal ofLightwave Technology*" *vol. 13, issue. 14,* March 1995, pp. 868–878.

[9] Surindersingh, R.S Kaler 1190km WDM transmission of 20 x 10 Gb/s RZ-DPSK signals using cascaded in-line semiconductor optical amplifier, "*Optics Communication Elsevier*",*vol, 276, issue, 2*, june 2007, pp. 105-115.

[10] Y. Mao , Z.G. Lu , j. Chrosotowaski, j. Hong, R. Misner, three-stage wave length converter based on cross-gain modulation in semiconductor optical amplifiers. "*Optics CommunicationElsevier*"*vol. 117, issue. 4*,Augsut 1999pp 57-66.