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Modeling of Semiconductor Optical Amplifier Gain Characteristics for Amplification and Switching

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Abstract: In this paper, investigations are made on performance analysis of the semiconductor optical amplifier (SOA).This analysis is done at 10Gb/s in terms of shifted wavelength conversion efficiency, quality factor (Q-parameter) and bit error rate (BER).The investigations are carried out by varying the probe signal wavelength and bias current of SOA and then according to that variations BER and Q factor graphs plotted.

Keywords: FWM, SOA, BER, Q.

I. INTRODUCTION

Semiconductor optical amplifier (SOA) technology has been exposed to the world due to its commercial values and future potential in fiber optic communication systems. The basic concept of the SOA is very similar to that of a laser diode operated around threshold bias, except that the SOA has an internal anti-reflection coating to reduce its reflectivity to nearly zero. Commonly, a SOA is used as an amplifier in communication networks to regenerate the optical signal at different points in the communications link by operating as a booster amplifier, in-line amplifier or as a preamplifier [1]. Besides amplification, SOAs can also be used as multi-functional elements in future all-optical switching, regeneration, and wavelength conversion schemes.

The effect of input power on SOA gain characteristics and Q-factor was initially investigated in our previous work. The purpose of this paper is to further simulate the performance of the SOA for improved amplification and switching functions. The SOA is modeled and simulated using OptSim software. The SOA is biased at an optimal 250mA to allow it to seen as both an amplifier and a switch. The SOA parameters used in the simulation are selected from a previous work [2]. A mathematical model is used to aid the design of the SOA and to predict the gain characteristics. The mathematical results are analyzed in order to verify the simulated results. Fig. 2, Fig.3, Fig.4, Fig.5 shows the gain characteristics when the SOA is simulated using OptSim.

II. SIMULATION SETUP

The simulation schematic of SOA system is shown in Fig. 1. The system consists of a few components such as laser power, attenuator, SOA, band pass filter, electrical gain amplifier and photodiode PIN. An optical power meter and electrical scope are used to measure the power signal and Q-factor respectively.

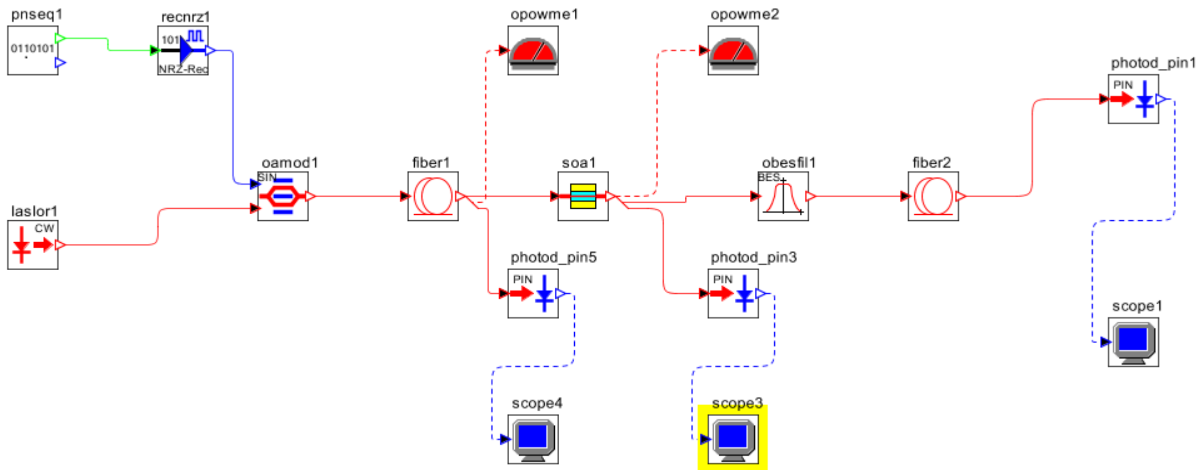

Fig.1:-Simulation schematic of SOA

III. RESULTS AND DISCUSSIONS

The output power increases with input power in the same ratio until the SOA saturates and the carriers in the active region become depleted, leading to a decrease in the amplifier gain. The SOA effectively operates as a constant gain amplifier before reaching its saturation value and the output signal is not affected by the SOA nonlinear response. This gain in the unsaturated region is measured to be around 45.7dB from the software, and the SOA starts to saturate at an output power of around 11 dBm also estimated from the curve. In order to verify the simulated results, mathematical analysis is done using these values inserted into a gain saturated rate equation from the many literatures [3] using Matlab and Microsoft Excel packages. The results are shown in Fig. 3. It can be seen that the gain difference between the simulated and mathematical results in the unsaturated region is < l dB. At the higher SOA inputs, the software simulation package inherent algorithms and iterations could not seem to match the ultrafast saturation dynamics of the SOA. Hence, there is a small offset mismatch in the saturated gain values.The paper has simulated the gain response of an SOA at a bias current of 250mA. The simulation result has been verified using mathematical analysis. The mathematical analysis is in good agreement with the simulation result, with only a small offset due to inherent software limitations in matching the gain dynamics of the SOA.

Table 1:Variation of Q-factor and BER with respect to Bias current of SOA(mA)

S. No.	Bias current of SOA(mA)	Q-factor	BER
1.	100	14.08861	$3.5731\text{x } 10^{-007}$
2.	120	10.77647	$3.1039\text{x}10^{-003}$
3.	140	9.410847	$1.3759\text{x}10^{-002}$
4.	160	9.776913	$8.43586\text{x}10^{-003}$
5.	180	9.465043	$1.2839\text{x}10^{-002}$
6.	200	11.43818	$9.84157\text{x}10^{-005}$
7	220	12.20398	$4.10324\text{x}10^{-005}$

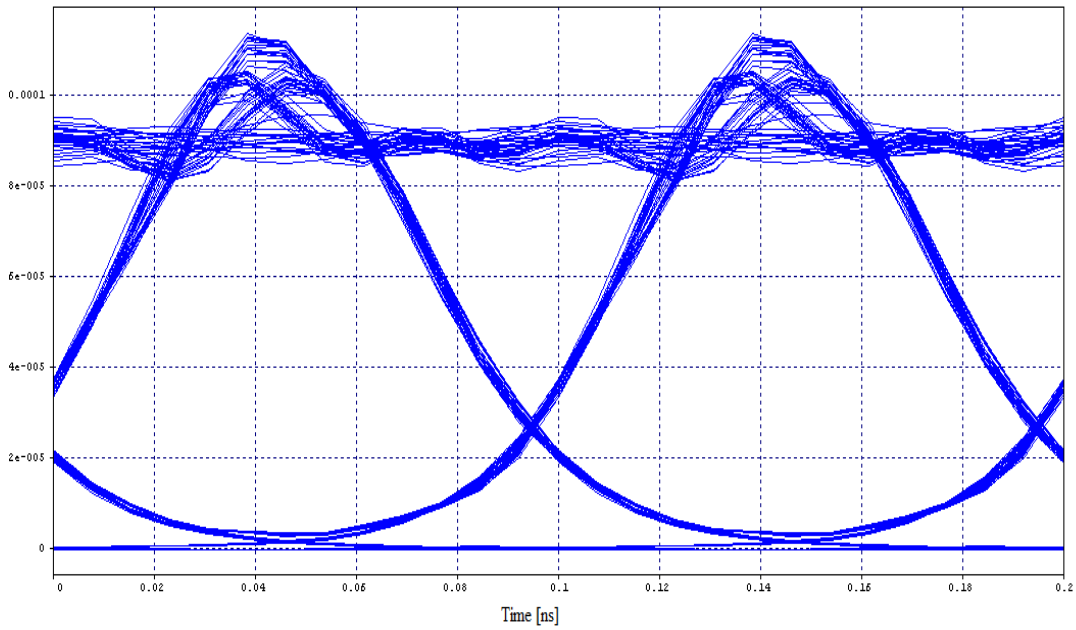

Fig. 2. Eye diagram of SOA

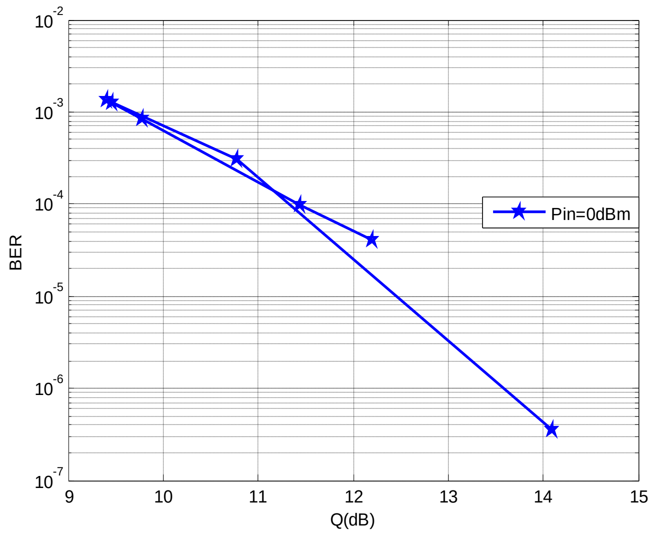

Fig.3. BER versus Quality factor(Q)

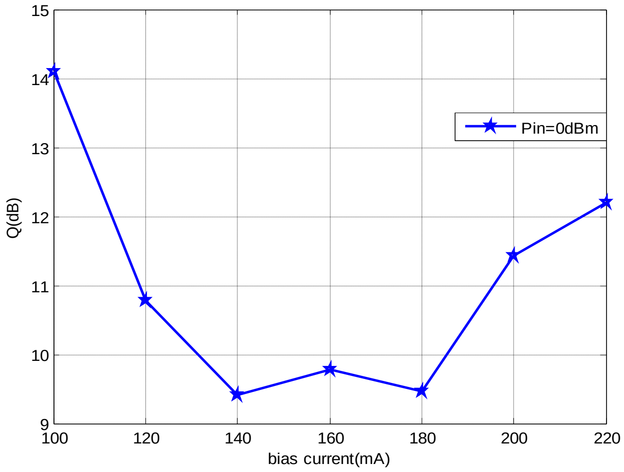

Fig.5. Quality factor(Q) versus bias current of SOA

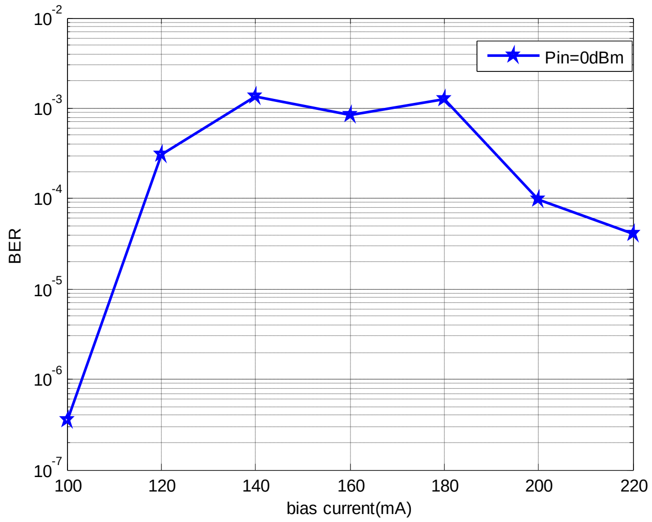

Fig.4. BER versus bias current of SOA

IV. CONCLUSION

We have simulated and investigated various effects of FWM wavelength conversion process that are occurring within SOA medium. The analysis has done by varying the wavelength of probe signal and current of SOA amplifier. Farah Diana [3] investigated the four wave mixing SOA based wavelength converter system for data rate of 2.5Gb/s but in this paper we have investigated the system for data rate of 10Gb/s. The quality factor (Q) and Bit error rate (BER) have been analyzed for 10Gb/s. The Q and BER is better at 100mA that is 14.08861 and 3.5731x 10^{-007} respectively.

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