International Journal For Technological Research In Engineering
Volume 1, Issue 11, July-2014 ISSN (Online): 2347 - 4718

ULTRAFAST ALL-OPTICAL INVERT LOGIC GATE DERIVED FROM SINGLE SOA BASED STRUCTURE

Rupinder Kaur[1], Simranjit Singh[2]
[1]M.tech Student, [2]Assi. Prof, Dept. Of ECE, Punjabi University
Patiala, Punjab, India.

Abstract: In modern era, the demand of optical signal processing is increasing to meet the growing need of speed and capacity in optical networks. This paper presents all-optical NOT logic scheme using only single Semiconductor optical amplifier (SOA). Cross gain modulation (XGM) effect has been exploited inside SOA for its operation. Its operation is demonstrated at 60 Gbps, however higher data rates operation can also be feasible by using SOA with shorter gain recovery time.
Keywords: Optical logic gates, SOA, XGM, Pump signal, Probe signal

I. INTRODUCTION

All-optical logic based devices are essential to get ultra-high speed all-optical networks. Particularly, all-optical Inversion operation is important in optical networks for conversion of data at one wavelength ($\lambda 1$) to another wavelength ($\lambda 2$). Inversion is readily accomplished using the gain saturation scheme in SOA. The gain saturation phenomenon is linked to both XGM and XPM [1].The speed of Invert operation based on gain saturation is limited by the gain recovery time of the SOA when XGM effect is used to implement its function [2]. Various schemes for realization of all-optical NOT operation have been previously reported such as 2.5 Gbps optical NOT logic based on semiconductor optical amplifier loop mirror [3], Optical Not Logic Based on Asymmetric SOA-Assisted Mach-Zehnder Interferometer [4], NOT optical gate using a reflective semiconductor optical amplifier for Manchester encoded signal [5], tri-state logical operation of optical NOT gate with the help of polarization encoded SOA-assisted Sagnac interferometric switch [6], 40 Gbps optical NOT logic operation using single SOA [7]. Wavelength conversion with good signal quality at 40 GB/s has been reported [8, 9]. Invert operation (or wavelength conversion) at higher bit rate has been reported using a SOA in conjunction with a delayed interferometer. [10]. The XGM characteristics based single structure SOA gates are easier to implement and good results have been achieved at higher bit rates. All-optical gates utilizing XGM reveal high conversion efficiency and polarization independence to input signals [11]. This paper demonstrates simple, polarization independent all-optical invert operation using a single SOA based structure. This is followed by using RZ modulated signals at 60 Gbps. The parameters are adjusted properly to obtain output pulses with minimum BER & maximum quality factor. Basic introduction to the All-optical NOT logic gate is given in first section. Second section defines design Setup & SOAs parameters. Section third describes results of all-optical NOT logic gates at 60 Gbps. Finally, conclusion is given in fourth section.

II. SIMULATION SETUP

The simulation setup is shown in Fig-1 was performed using software tool Rsoft's OptSim. The continuous wave (CW) Lorentzian laser source namely CW Laser is taken to generate the wavelength of data signal. The laser source is then modulated according to the data provided by the user in the custom file of the pseudo random binary sequence (PRBS) generator. PRBS can also be used with deterministic type that defines different polynomial number to generate different data sequence. The data signal is then amplified using EDFA amplifier, then pass to optical coupler. Another CW Lorentzian laser, CW Laser2, for generation of probe signal wavelength is taken with FWHM as 10MHz. The wavelengths of data and probe signals are given in Table1. The data signal is coupled with the probe signal through optical coupler and then given to SOA where nonlinear processes take place to get the switching action. The moderate saturation regime for obtaining the NOT operation is selected by using an optical band pass filter, BPF, tuned at wavelength 1557.3 nm. The various parameters used in simulation are listed in Table1.

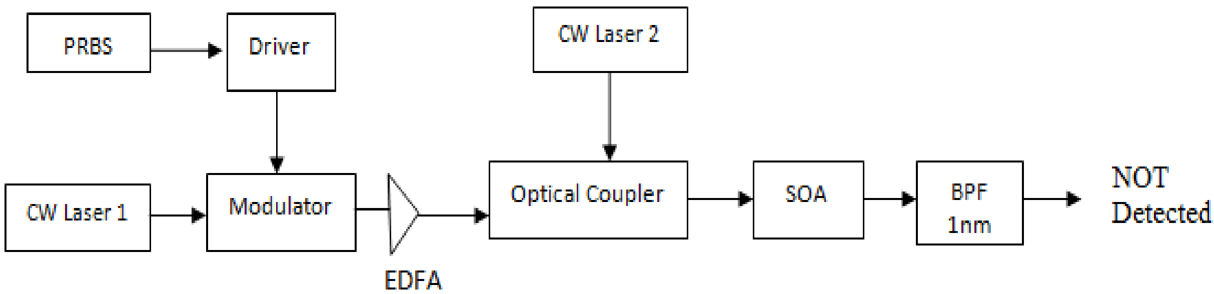

Fig. 1- Simulation setup of single SOA based all-optical NOT logic

Table 1: The list of parameters used in the simulation

Parameter	**Value**
Bit rate	60 Gbps
Wavelength of Data1	1549.3 nm
Wavelength of Data2	1550.7 nm
Wavelength of probe	1557.3nm
Gain of EDFA	25 dB
Bias current of SOA	500 mA
Length of SOA	300 μm
Active Layer Width of SOA	1.5 μm
Active Layer thickness of SOA	.15 μm
Spontaneous carrier lifetime	300 ps
Transparency carrier density	1×10^{18} cm^{-3}
Material gain constant	3×10^{-16} cm^{-3}
Material Loss	10.5 cm^{-1}
Input/output insertion loss	3 dB
Confinement factor of SOA	.4
Linewidth enhancement factor of SOA	3

III. RESULT & DISCUSSIONS

SOA nonlinear processes are used for various switching functions & applications. The output waveform simulations for all-optical NOT logic gate is performed using RZ raised cosine modulated signals at 60 Gbps by using the listed parameters shown in Table-1. Input signal waveform of data signal and resulted NOT output waveform can be observed in Fig-2a and Fig- 2b respectively. The eye diagram of NOT logic at 60 Gbps is shown in Fig-2c. The input power levels and the optical BPF center wavelength are selected properly for optical logic function realization as XGM depends on input power and bias current to deplete the carrier concentration in active region of SOA.

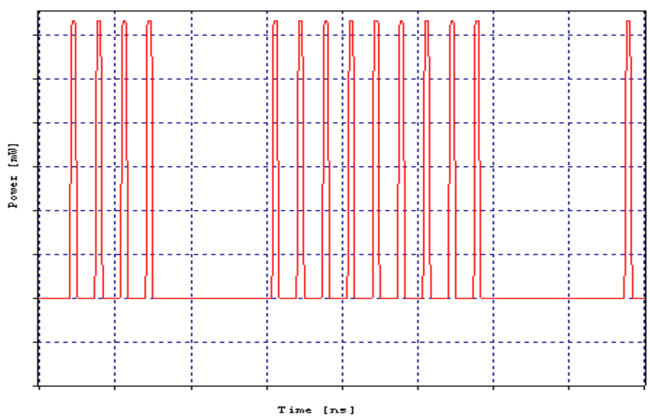

Fig 2. Optical intensity waveform of input data signal

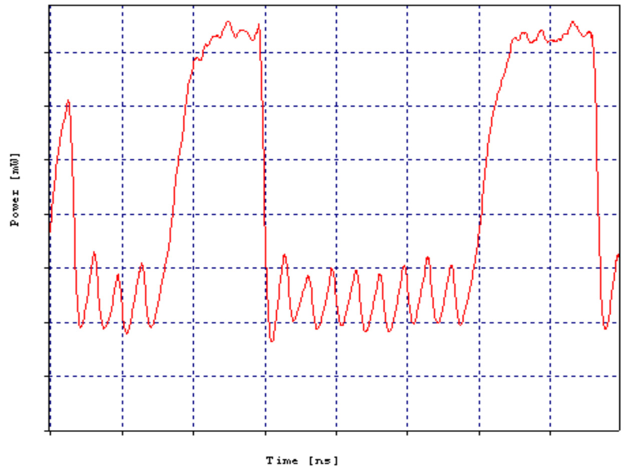

Fig 3. Resultant NOT logic at 60 Gbps

Higher bias current requires lower total input power in order to enable the XGM effect to occur in SOA.

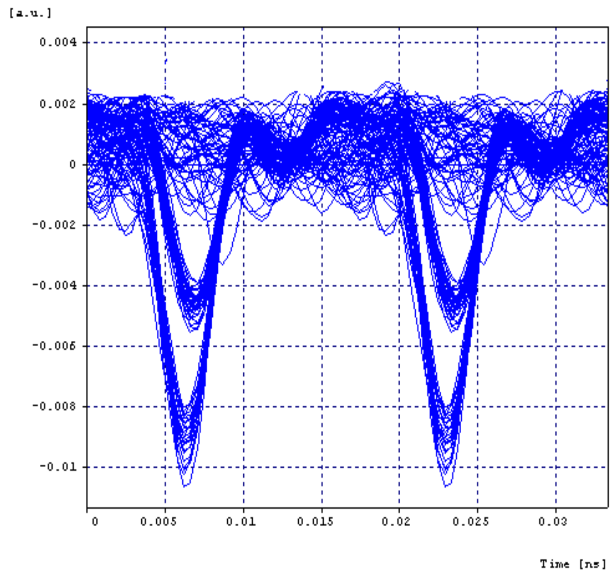

Fig 4. Eye diagram of resultant NOT logic at 60 Gbps

The data signal at .316 mW power level and probe signal at 5 mW power is used in simulation to get desired NOT operation. The nonlinear operation used is XGM; when data signal along with probe signal shot together simultaneously into SOA, then the probe signal is gain-modulated with polarity-inverted output. BPF is tuned to 1nm bandwidth for NOT operation detection.

IV. CONCLUSION

All-optical NOT logic has been successfully demonstrated at 60 Gbps. The logic operation is obtained by exploiting XGM in SOA. The minimum achievable bit error rate and maximum quality factor simply called Q-factor are 4.27*10e-20 and 19.6 dB respectively which is quite acceptable. The simplicity of design and results show SOA-XGM based NOT operation offer good inversion switching performance.

REFERENCES

[1] Agarwal G.P.,"Applications of Nonlinear Fiber Optics," Academic Press, San Diego, CA, 2001
[2] Niloy K Dutta & Qiang Wang,"Semiconductor Optical Amplifier," World Scientific Publishing Co. Pte. Ltd, 2006
[3] Wang Ying, Zhang Xin-Liang and Huang De-Xiu, Chinese Phys., 13, 6 (2004)
[4] Xiaohua Ye, Xuguang Huang and Surinder Singh, Bulletin of Electrical Engineering and Informatics, 1 (2012) 313-322
[5] Zhefeng Hu and Junqiang Sun, Optica Applicata, XL (2010) 57-61
[6] Tanay Chattopadhyay andJitendra Nath Roy, "Semiconductor optical amplifier (SOA)-assisted Sagnac switch for designing of all-optical tri-state logic gates", Optik, 122 (2011) 1073–1078
[7] Sanmukh Kaur and Rajinder-Singh Kaler, Journal of the Optical Society of Korea, 16 (2012) 13-16
[8] B. Mikkelsen, K. S. Jepsen, M. Vaa, H. N. Poulsen, K. E. Stubkjaer, R. Hess, M. Duelk,W. Vogt, E. Gamper, E. Gini, P. A. Besse, H. Melchior, S. Bouchoule and F. Devaux, Electron. Lett. 33, 2137 (1997).
[9] J. Leuthold, C. H. Joyner, B. Mikkelsen, G. Raybon, J. L. Pleumeekers, B. I. Miller, K. Dreyer and C. A. Burrus, Proc. Opt. Fiber Comm. Conf. (OFC), Washington DC, 4, 218 (2000).
[10] [10] J. Leuthold, C. H. Joyner, B. Mikkelsen, G. Raybon, J. L. Pleumeekers, B. I. Miller, K. Dreyer and C. A. Burrus, Electron. Lett., 36, 1129 (2000).
[11] M.C. Tatham, IEEE Photonics Lett., 5 (2001) 1303-1306
[12] K. E. Stubkjaer , IEEE J. select Top. Quantum Electron. 6, 6 (2000) 1428-1435
[13] Surinder Singh and Lovkesh, IEEE J. Quantum Electron., 18, 2 (2012) 747–751
[14] Jae Hun Kim, Young Il Kim, Young Tae Byun, Young Min Jhon, Sun Ho Kim & Deok Ha Woo, Journal of the Korean Physical Society, 45, 5 (2004) 1158-1161

