Design and Investigations for SOA with Fiber as optical Switch

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***Abstract*— The article explores design and performance investigation for all optical switching action. The non-linear behavior of the semiconductor optical amplifier with optical fiber constructs it to execute as an optical switch. Accordingly, with raised cosine non return to zero pulse pattern numerical simulations have been verified for the optical gates switching action, in support the inverter operation achieved at data rate of 20Gbps altogether with good extinction. Numerically simulated results depicted that performance rely upon the key parameters as semiconductor optical amplifiers pump current, laser input power and the modulator bias voltage. This also inferred that, it is a competent structure owing to its key attributes of low power need, simplicity and stability altogether with integration capability, could be a significant assist to the optical signal processing.**

Keywords- switching networks (SN); optical switching (OS); Mach-Zehnder Interferometer (MZI); fiber optic communication (FOC)

I. INTRODUCTION

The communication, computer networks particularly the internet are swiftly altering the present world's scenario significantly. As incessantly newest applications have been extensively included to the preexisting networks. So, it turned out to be overcrowded and leading to crisis for bandwidth at the core wide-area network level as a consequence degrades the quality of service. For that optical fiber networks were broadly exercised with their proven performance in the background through optical fiber as basic mode of communication, designed in such a way to exploit its unique attributes. Accordingly, numerous fiber optic communication (FOC) multiplexing techniques were exercised with their respective pros and cons. FOC multiplexed schemes are widely accepted and employed for point-to-point and for long-haul networking which transports gigantic data in a cost-effective way. Accordingly for that customary switches employed to interconnect optical fiber lines were electro-optic. Thus one of the vital concerns is the O/E/O (optical/electronic/optical) conversions in the network and as the data speed further increases the electronic switching nodes were incapable to sustain [1-4].

As well as electronic equipment are robustly reliant upon protocol and data rate. So as to sustain with higher data speed pre-existing network is to be upgraded by swapping the electronic switching apparatus which further raises the network cost. Accordingly it propels towards the design of next generation switching networks (SN) in order to control massive data transfer and gives rise to concentration on the study of all-optical fiber-optic switching device which sustains it as the light signal from input to output. It is well widely accepted in photonic computing technology systems. Accordingly it have prospect for fast switching, high speed and exploiting the vast bandwidth of the fiber. The all O-O-O (optical) switches were well extensively exercised in a DWDM node where an optical switch appends manageability. Which could likely grow up to numerous channels and thus grasps the pledge of managing light signals without converting it to electrical and then back again [5 -10].Whereas the study explored for the electrical domain electrical signal controls the switching function and restricted to low data rates while with all optical switches relies on the control of light by light. Realized with Mach-Zehnder Interferometer (MZI) by altering the phase difference in between the light beams with employed 3-dB coupler splits the signal in to two beams. It passes through individual arms of same and other 3-db coupler to combine them subsequently divides again to get switch action. Further for high-speed optical time division multiplexing (OTDM) link demonstrated that when the data rate surpasses the speed of electronics the all optical switches are a necessity [11-13]. However altogether with tremendous study on this track in the upcoming time the requirement of high- capacity transmission is estimated to further augment considerably owing to the start of new high-speed access systems and bandwidth-hungry applications. So the requisites on the network elements will go on rise. Accordingly the next-generation switching and routing components must have to be capable to maintain rapidity with these growths and ought to endow with an increased throughput in a dynamic way. However the prediction about which technology and architecture may dominate in the upcoming time it is quite a complex issue. Accordingly the all-optical switching (OS) along with superior flexibility, low power consumption, granularity and switching capacity could be capable to meet up the complexity of present data traffic prevailing over this mounting possibility. For that incessant concentrated investigations are must to be executed.

In this view, performance is to be investigated for the proposed optical link to perform as an optical switch, designed with optical fiber and semiconductor optical amplifier. In the next segments it illustrates the schematic presentation, results and discussions accordingly.

II. THE DESIGN PRSENTATION

The proposed schematic for the performance study is as shown in the Fig.1. This schematic is used to perform the switching action, works as on (1-state) and off (0- state) switch. Here the pseudo random binary signal (PRBS) source generates the desired input pattern of 20Gbps which after modulation passed thorough optical fiber. Then the data signal is given to semiconductor optical amplifiers (SOA) which operate as a switch in accordance to the applied current. Here in the two arms two SOA's are used, out of which in the upper arm SOA is set to OFF state that is pump current is set to zero ,whose output further passes through the detector and finally the detected output shown on the scope-1, shows the original pattern.

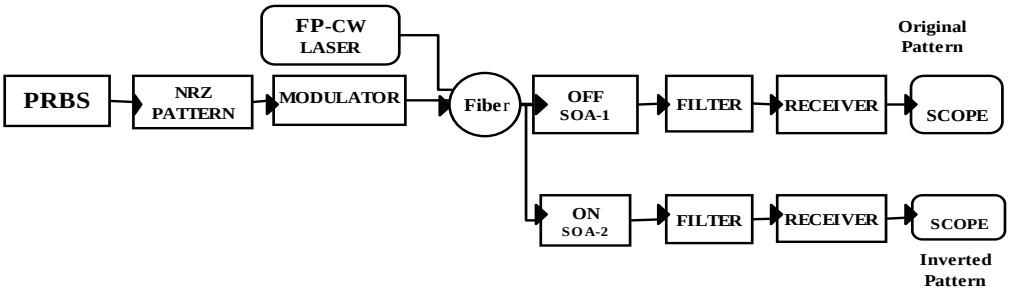

Figure1.The proposed schematic

The modulated output after passing through the fiber is passed through the ON state SOA with pump current set to 0.10A and the detected output is passed through the scope, which is the corresponding OFF state output that is the inverted output on the output scope, owing to the fiber nonlinearity and as the carrier dynamics within the ON state semiconductor optical amplifier is quick and the gain act in responses with the variations in power input on bit-by-bit basis. At the receiving end optical filter and detectors and output scope is employed to observe the output pattern detected from the lower and upper detectors. A bit error rate tester is also used for the necessary performance measurement which measure extinction ratio, bit error rate.

III. RESULTS AND DISCUSSION

The all-optical switching operation is a one of the key component to realize modern all-optical communication networks. For that an optical link has been designed and their performance investigated with assist by fiber and semiconductor optical amplifier as shown in Figure (1). With the purpose to evaluate the performance of the optical switching action at a data rate of 20Gbps, a continuous wave with wavelength of 1550 nm is with laser power set at 21W is generated by Fabry Perot laser which is modulated with chirp factor 0.5.The desired signal pattern is generated with Pseudo-random binary sequence (PRBS) which is driven by raised cosine non return to zero (NRZ) pulse and further signal is modulated using Mach–Zehnder modulator with point per bit 2^5-1**.**For the simulation of desired switching action the length of fiber is half meter with loss 0.25dB/km and **t**he bias voltage of modulator is set at 0.95,current injection efficiency of 1.5 . For the active length is 8e-4, width is 3e-6, thickness is 1.5e-7 and SOA pump current is set at 1.5A.The modulate signal pattern passed through a fiber of one meter of length and further through the two arms which consists of SOA out of which one is with zero pump current and other lower branch is having applied pump current .The investigated results as explored in the Figure (2). To Figure (8).

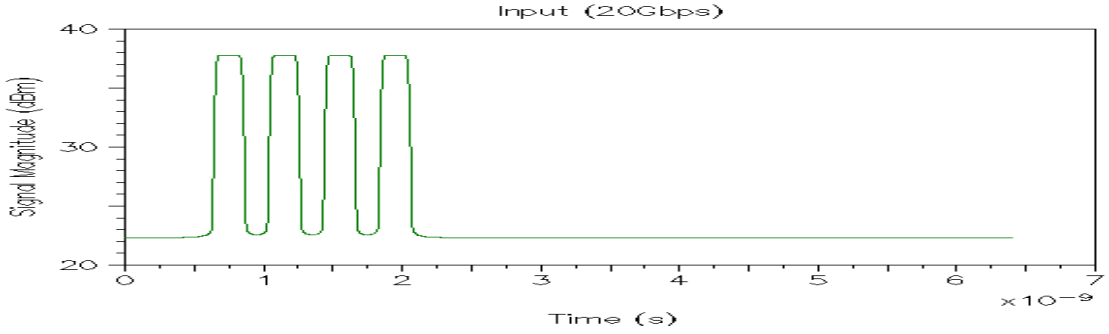

Figure 2. Input pattern [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0 0 1 1 1 1 0 0 0 0 0 0 0]

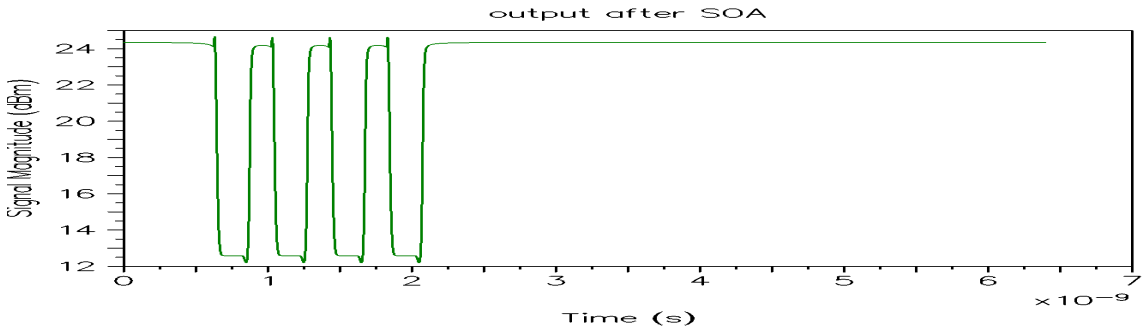

Figure3. Output pattern after SOA

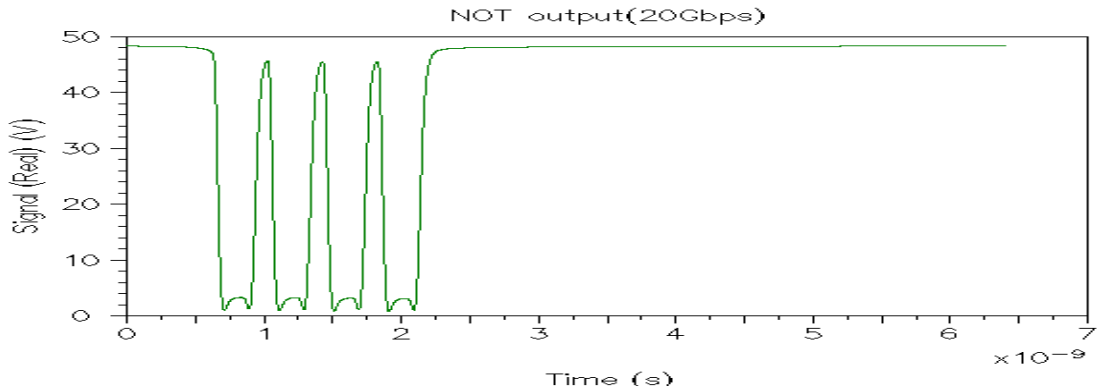

Figure4. Detected Inverted (OFF) output for ON SOA

Figure 2 shows the input pattern [0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0 0 0 0 0] to be investigated and Fig.3 depicts the output generated after the ON SOA that us corresponding to the applied pump current .The corresponding detected output after passing through their respective detector is as illustrated in the Fig.4.It depicts inverted output this arm 2output can also be considered to as OFF state output. Here the stated switching action and inverter logic action is achieved as the gain of a semiconductor optical amplifier reliant upon the applied to input power as well, as the carrier dynamics within amplifier is quick. The Fig.5 depicts the output after passing through the first arm SOA which OFF, that is pump current is 0A.The resultant output is same as input pattern. In this state it is considered as ON output i.e. ON switch.

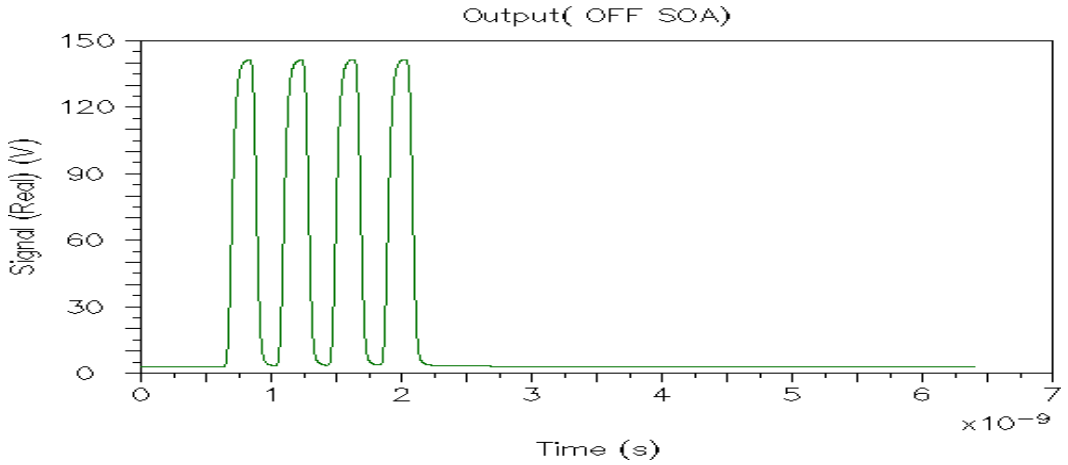

Figure5. Output with arm two (OFF SOA)

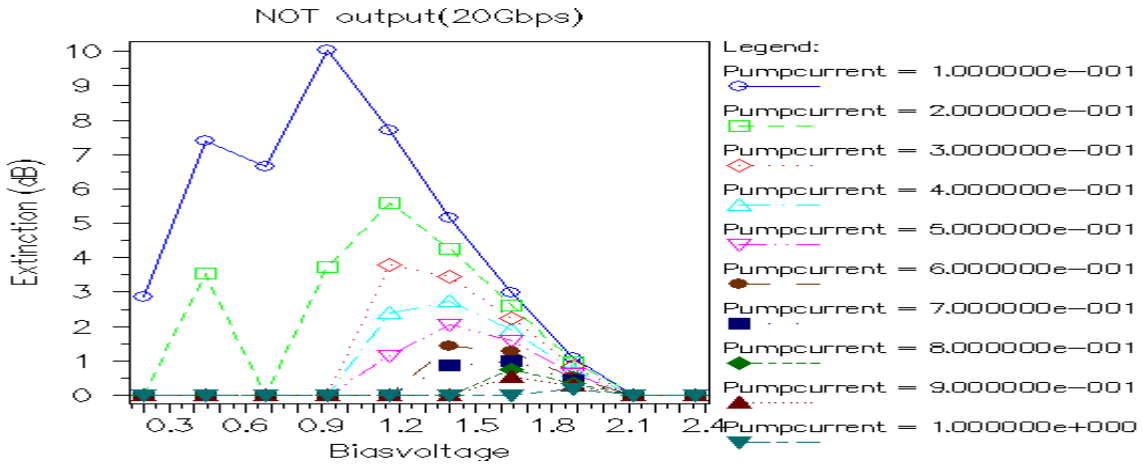

Figure6.Plot for Extinction vs. Bias voltage vs. SOA pumcurrent

Figure5 depicts the resultant plot for extinction ratio vs. bias voltage vs. SOA pump current obtained for a parametric scanning, reveals good extinction achieved for low pump current and for the bias voltage of 0.95v.For the performance measure extinction ratio is picked as optimization standard, the correlation of the powers utilized in transmitting a logic level one to the logic level zero. It is the efficiency with which transmitted optical power is modulated over the transmission system.

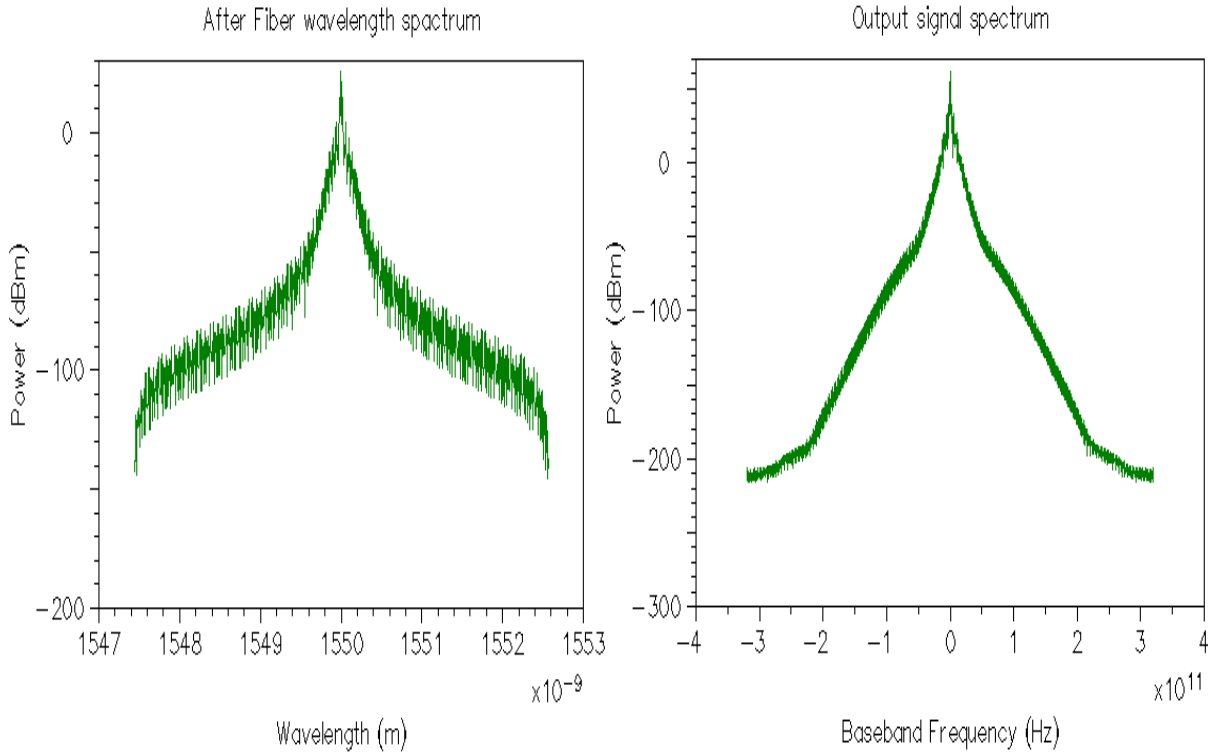

Figure7 (a) &(b). The received optical spectrum

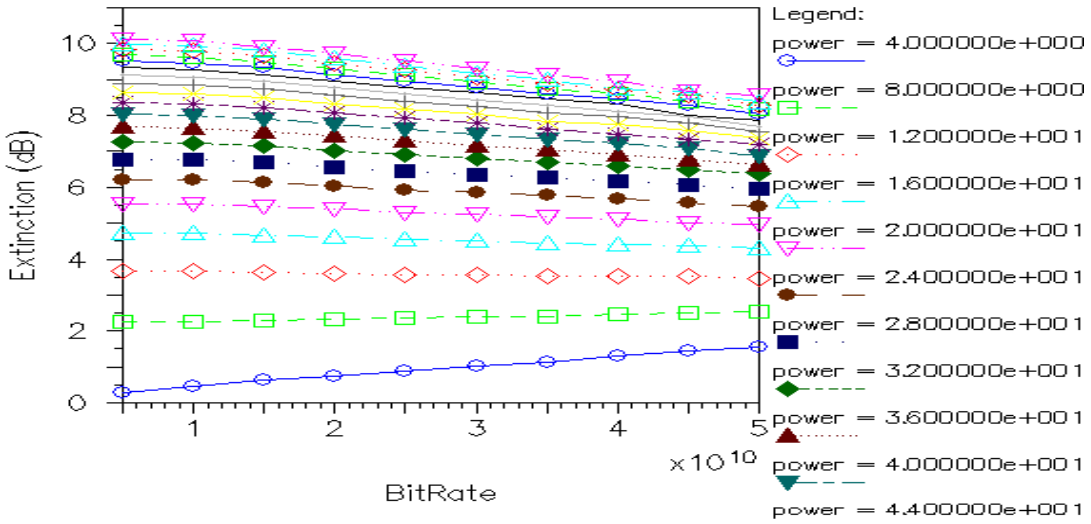

Figure8. Extinction vs. bit rate vs. laser power

Figure7 (a) and Figure7 (b), depicts the corresponding output signal wavelength and frequency spectrum after fiber and detector, which are as acceptable. Whereas the numerical simulation for the bit rate vs. laser power and extinction is as illustrated in the Fig.8.It depicts that good performance as the extinction vary with laser power and bit rate though it sustained good performance for the laser power of 20w.

IV. CONCLUSION

All-optical switching will play vital role in future for high-speed optical communication networks. For that all optical switching network have been designed and its switching action successfully verified for the inputs operating at a data rate of 20Gbps.Numerically simulated results depict that links performs as inverted output in which case it execute as an OFF state switch. While in the other branch with semiconductor optical amplifier with zero pump current the original input pattern is observed that is ON state switching action. It depicted very good extinction factor altogether with the applied bias voltage of 0.95volts and for low pump current of semiconductor optical amplifier. This design could be straightforwardly and effectively be enlarged and could be exercised for numerous input digits. The study also reveals that as soon as optoelectronic integrated circuit technology will grow up the cost goes down, the use of semiconductor optical amplifier as a fundamental switch and as an element in practical subsystems will enlarge.

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