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Simulation of high speed compressors using SOA-MZI

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ABSTRACT
The rapid growth of the Internet demands faster data transmission speeds and consequently larger bandwidths that electronic circuits unable to provide.. So optical computing is the most promising way to handle huge volume of data at high speed. Wallace tree multiplier can be improved by using compressor methods. To achieve this goal, all-optical compressor circuit using Mach–Zehnder interferometer (MZI) is explored in this paper. This paper describes high speed compressors using SOA-MZI based XORs and multiplexers.
KEYWORDS: *Compressor, Semiconductor optical amplifiers (SOA), Mach–Zehnder interferometer (MZI).*

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I. INTRODUCTION

The need of high speed computing has created a pressing demand for realization of electronic circuits with miniaturization limit. In order to overcome the electronic bottlenecks and fully exploit the advantages of optics, All- optical switching by reversible logic gates, i.e the switching of one beam of light by another is an essential technique for transparent fiber optics networks and for all forms of optical information communication, where the transmitted data would remain exclusively in the optical domain without optical-electrical-optical (OEO) conversionsToday's digital signal processing, Multiplier like, binary multiplier, tree multiplier, Array multiplier etc. plays an important role. On the other hand, high speed multiplier is an essential requirement for all multiplication methods. A Wallace tree is also a very useful hardware function that is used in digital circuit for multiplies two integers. The speed of a multiplier determines its performance and it is improved by compressor circuit [1]. SOA based MZI can important role for high speed computation [2]. The prime contributions of this work are precisely given as:

• Compressor using MZI switches.
• Low power utilization
• Higher execution speed.

The paper is further oriented as follows: The working principle of MZI is reported in Section II. Section III presents the compressor circuit design using MZI based switches. Section IV shows performance evaluation and finally the conclusion and future scope of the work are presented in Section V.

II. WORKING PRINCIPLE OF MZI

The schematic diagram of the MZI-SOA all-optical switch is shown in Fig. 1. Here two SOAs (SOA-1 and SOA-2) are inserted in each arm of an MZI [3-5]. This switch also has port-1 and port-2 two input ports and port-3 and port-4 two output ports. The incoming signal pulse of wavelength λ_2 is enters at port-1and it is divide uniformly by the coupler C1 (50:50) and propagates in the two arms of the MZI at the same time. At this time port-2 is kept open. At the same time, the controlled pulse of wavelength λ_1 enters to the upper arm through coupler C2 so that the majority power passes through the upper arm, so, SOA-1saturates and its index of refraction changes, and at the same time, the SOA-2 gets the unsaturated gain. So, a differential phase shift can be achieved between the data signal of two arms. Hence, light is present in the port-3 (bar port), as shown in Fig. 1. In this case, no light is present in the port-4 (cross port). On the other hand, when the control signal is absent, both SOAs (SOA-1 and SOA-2) get the same unsaturated. In this case, no light is present in the port-3 (bar port), then light is present in the port-4 (cross port). For blocking the control signal of wavelength λ_1 signal, optical filters (F) are placed in front of the output ports. As MZI does not reverse the bit pattern, so the MZI scheme is preferable to cross-gain saturation and it results in a higher ON-OFF contrast simply because nothing exists from bar port during 0 bits.

Now, it is clear that in the absence of the control signal, the incoming signal exits through the port-4(cross port) of MZI as shown in Fig. 1. In this case, no light is present in the port-3 (bar port). But in the presence of the control signal, the incoming signal exits through the port-3 (bar port) of the MZI as shown in Fig. 1. In this case, no light is present in the port-4(cross port). In the absence of an incoming signal, the port-3 (bar port) and port-4(cross port) receive no light as the filter blocks the control signal. Fig. 2 represents the schematic block diagram of the MZI and Truth table of Fig. 2 is given in Table 1.

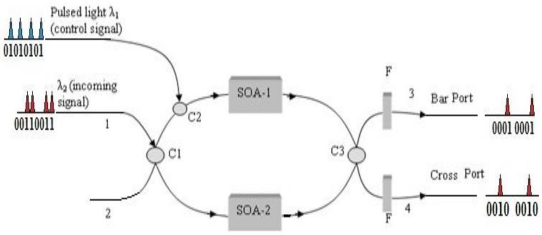


Fig. 1: MZI-based optical switch

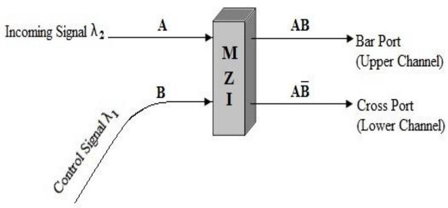


Fig. 2: Schematic diagram of SOA based MZI optical switch

Table 1. Truth Table of Fig. (2).

Incoming Signal	Control Signal	Output Port-1	Output Port-2
0	0	0	0
0	1	0	0
1	0	0	1
1	1	1	0

At port-3 and port-4 the intensity transmission characteristics can be expressed as

$$T_3(t) = \frac{1}{4} G_1 \left\{ k_1 k_2 + (1 - k_1)(1 - k_2) R_G - 2\sqrt{k_1 k_2 (1 - k_1)(1 - k_2) R_G} \cos(\Delta\Phi) \right\} \quad (1)$$

$$T_4(t) = \frac{1}{4} G_1 \left\{ k_1 (1 - k_2) + (1 - k_1) k_2 R_G - 2\sqrt{k_1 k_2 (1 - k_1)(1 - k_2) R_G} \cos(\Delta\Phi) \right\} \quad (2)$$

Where $R_G = G_2/G_1$, G_1 and G_2 are the time-dependent gain,
$\Delta\Phi(t) = -\frac{\alpha}{2} \ln\left(\frac{G_2}{G_1}\right)$,, α is the linewidth enhancement factor (taken 7.5 here), k_1 and k_2 are the ratios of the couplers C1 and C2 respectively. For simplicity, we take $k_1 = k_2 = 1/2$. The output signal power at port-3 and port-4 are,

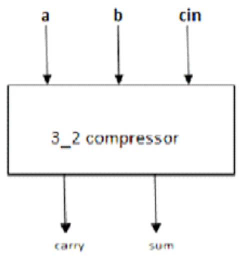
$$P_j(t) = P_{ip}(t).T_j(t), \qquad j = 3, 4 \quad (3)$$

Where $P_{ip}(t)$ is the power of the incoming signal pulse. When both beams are present simultaneously, the control pulse saturates SOA-1 on the change in carrier density inside SOA.

III.A. 3:2 COMPRESSOR CIRCUIT DESIGN USING MZI BASED SWITCHES

The 3:2 compressors provide higher performance than that of the full adder based design [9]. The block diagram of 3:2 compressors is shown in Figure 3 and its truth table is given in Table 2.

Table 2: Truth table of Fig.3



a	b	C_{in}	sum	carry
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

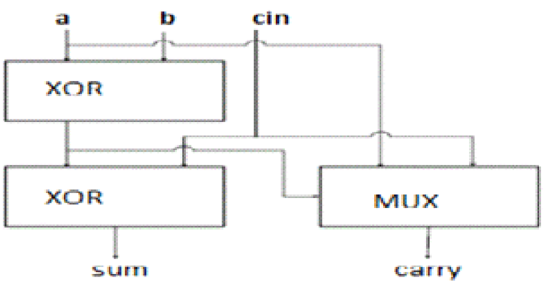
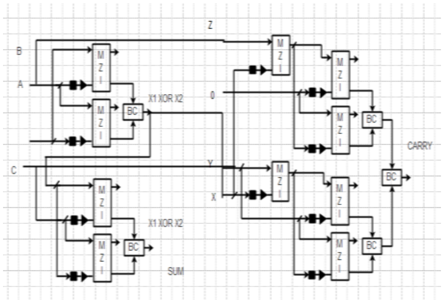


Fig.3: Block diagram of 3:2 compressor.

Fig. 4: XOR and MUX based 3:2 compressor.

Conventional 3:2 compressor circuit diagram is shown in Figure 4 and it is implemented by MZI which is shown in Figure 5.



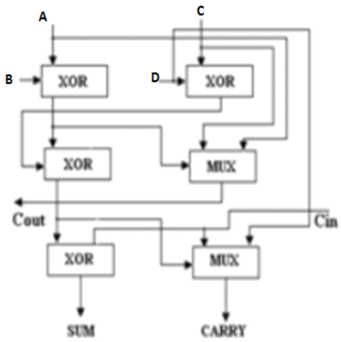
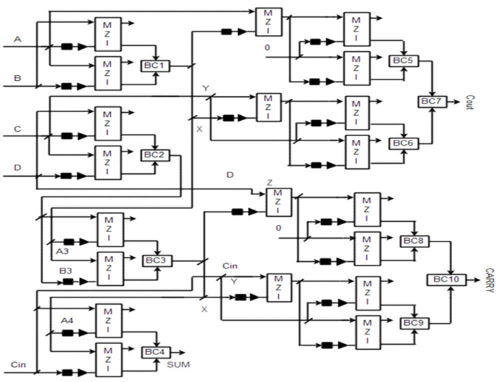


Fig. 5: 3:2 compressor circuit using MZI.

III B. 4:2 COMPRESSOR CIRCUIT DESIGN USING MZI BASED SWITCHES

The 4:2 compressor having the maximal delay of three XORs is shown in Figure 6. This multiplexer based design provides higher performance than that of the full adder based design. The truth table of figure 6 is shown in table 3.

Fig. 6: XOR and MUX based 4:2 compressor.



				Cin=0			Cin=1		
A	B	C	D	Cout	Carry	Sum	Cout	Carry	Sum
0	0	0	0	0	0	0	0	0	1
0	0	0	1	0	0	1	0	1	0
0	0	1	0	0	0	1	0	1	0
0	0	1	1	0	1	0	0	1	1
0	1	0	0	0	0	1	0	1	0
0	1	0	1	0	1	0	0	1	1
0	1	1	0	1	0	0	1	0	1
0	1	1	1	1	0	1	1	1	0
1	0	0	0	0	0	1	0	1	0
1	0	0	1	0	1	0	0	1	1
1	0	1	0	1	0	0	1	0	1
1	0	1	1	1	0	1	1	1	0
1	1	0	0	1	0	0	1	0	1
1	1	0	1	1	0	1	1	1	0
1	1	1	0	1	0	1	1	1	0
1	1	1	1	1	1	0	1	1	1

Table 3: Truth table of Fig.6.

The 4:2 compressor is implemented using MZI is shown in Figure 7. Here A, B, C, D, and Cin are five inputs and three outputs.

Fig. 7 : 4:2 compressor circuit using MZI.

IV. RESULTS and DISCUSSIONS

This section indicates the performance evaluation through simulation by Opti-system V-3.0. The simulated circuit diagram and output of the 3:2 compressor are shown in Figure 8 (a) and Figure 8 (b) respectively. The simulated circuit diagram and output of the 4:2 compressor are shown in Figure 9 (a) and Figure 9 (b) respectively.

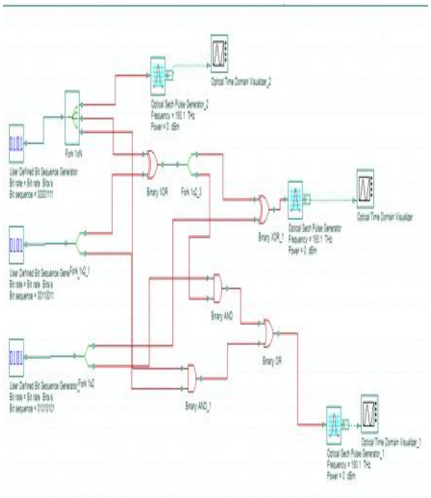


Fig. 8(a): Simulated circuit diagram of 3:2 compressor

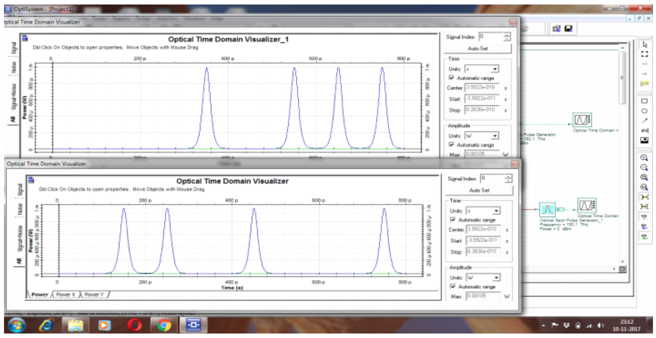


Fig. 8 (b).: Output waveform of Fig. 8 (a).

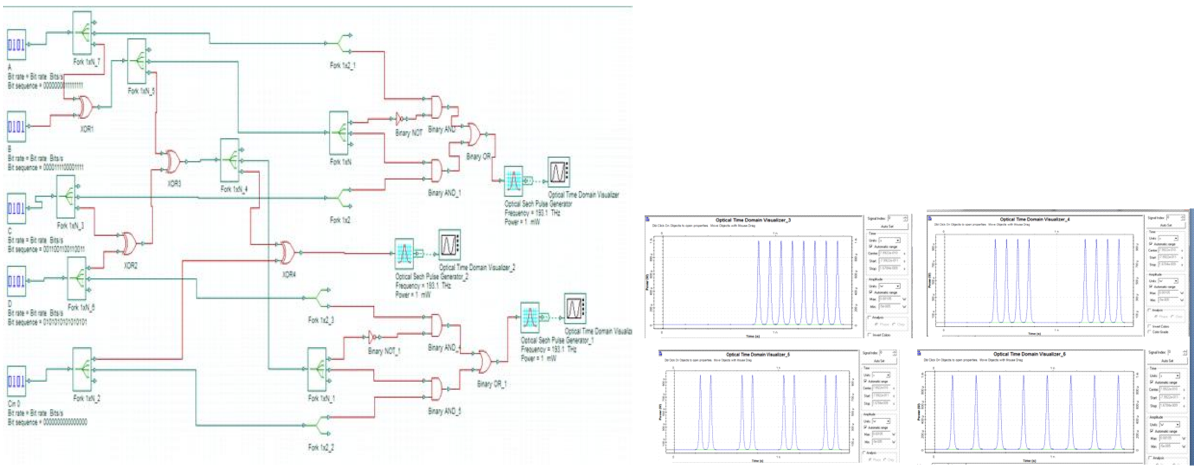


Fig. 9 (a): Simulated circuit diagram of 3:2 compressor.

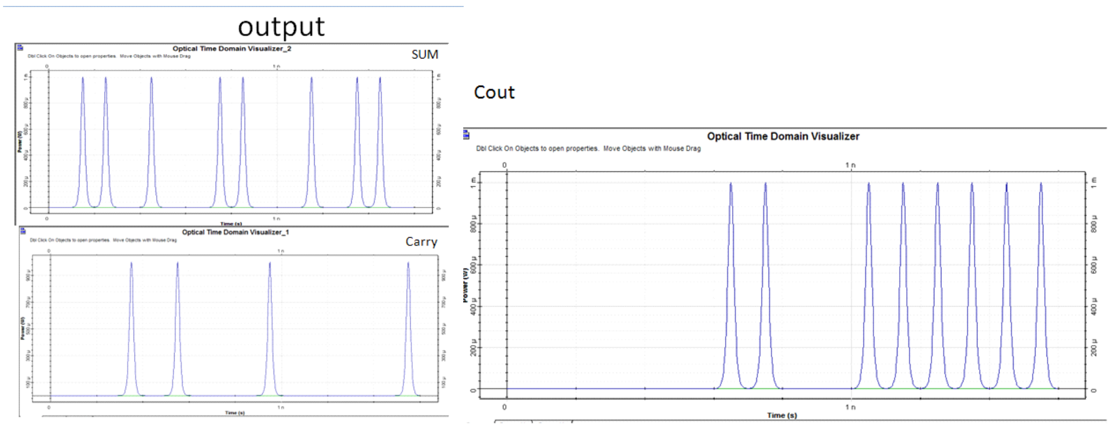


Fig. 9 (b).: Input and Output waveforms of Fig. 9 (a).

V. CONCLUSION

Here our aim is to implement all optical logic and information processing systems using non linear material based switches. One of the most promising new technologies is optical computing, where the traditional information carrier electron is replaced by photon This paper proposes all-optical 3:2 and 4:2 compressors are design using MZI. These compressors use a different configuration for XORs and Multiplexers. It has been seen that these design are very much effective in terms of power consumption and delay. A binary tree can be constructed by using a row of 4:2 compressors, which accepts 4 numbers and sums them to produce two numbers. This circuit facilitates high parallel computing capability with small energy dissipation and it communicates huge volume of data at high speed in the optical domain.

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