Modelling of All Optical Adders using Dispersion Managed Solitons

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***Abstract*— The need for high bit rate circuit is increasing day by day.Inorder to overcome the bitrate limitation caused by electronic signal processing All Optical Processing (AOP) is required. AOP deals with realising digital circuits using optical elements only. All optical adders are modelled using suitable combination of AND ,OR and XOR gates utilising Cross Gain Modulation (XGM) effect in SOA. In this paper all optical full adder and half adder are modelled using Dispersion Managed (DM) solitons as input pulse and utilising XGM in SOA at 100 Gb/s.**

Keywords: Dispersion managed solitons, Semiconductor optical amplifier, AND gate, OR gate, XOR gate.

I. INTRODUCTION

Solitons are non linear pulses that maintain their shape as they propagate over long distances. Solitons are caused by the cancellation of non linear and dispersive effects in the medium. Till date in most of research works RZ, NRZ and soliton pulses are used for transmitting high data rate information in optical fiber over transoceanic distances. When soliton pulses become short effects such as raman self frequency shift, third order and linear fiber losses creep in and distort the propagation of pulse. Generally these limitations can be reduced with the usage of optical solitons incorporating Dispersion Management.

Dispersion Managed solitons offer many advantages over conventional optical solitons. DM solitons provide great oppurtunity in conventional long haul communication because of their superior characteristics which are not achievable in conventional long haul communication system. DM soliton can propagate a transmission line with zero or even normal average dispersion. Operating in zero dispersion can in principle eliminate Gordon Haus jitter. Dispersion managed (DM) solitons have their energy enhancement factor as compared to traditional solitons due to which they can provide higher signal to noise ratios at the receiver [1].

All optical logic gates are the key components in all optical signal processing. All optical gates have recieved considearable attention due to their numerous potential application in optical signal priocessing systems such as bit error rate monitoring, optical bit pattern recognition, all optical packet address and payload seperation.

All optical AND, OR and XOR gates are realized utilising SOA and tunable filter. Different gates are realised by properly optimizing the tunable filter. These gates can further be used in suitable combinations to realize higher level digital components like half-adder, full adder, flip-flop, shift registers, etc. This in turn shall aid the development of all-optical computers and processing [2].

In all optical computing switching, arithmetic operations and storage are the basic functions. For arithmetic operations, half adder is proposed which can simultaneously produce sum and carry.

In this paper all optical half adder and full adder are modelled using DM solitons as input pulses and utilising XGM effect in SOA.

II. SYSTEM DESIGN

The design model for half adder contains AND gate and XOR gate. Sum is generated using AND gate and carry is generated using XOR gate. For this purpose, Cross Gain Modulation which produces non-linear effect in SOA cavity is used. Two high power control pulse (pump) and two low power probes are used. Block diagram for modelling half adder is shown in figure 1. The two inputs data1 and data 2 along with probe 1 is coupled and is subsequently multiplexed. The multiplexed output is passed through SOA and optical filter where gating operation occurs. Here carry is generated by AND logic. Similarly Data 1 and data 2 along with probe 2 is combined to generate the sum by XGM in SOA and optimizing the filter. Sum is generated by XOR logic [3].

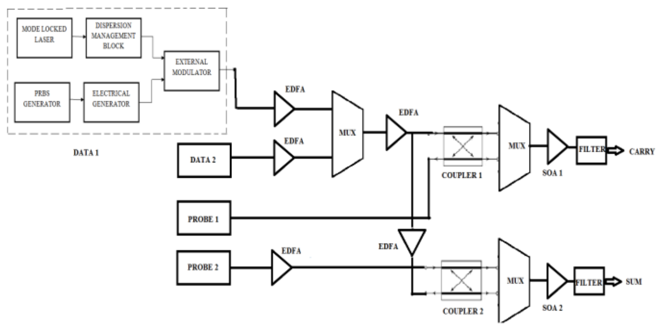

Figure 1: Block diagram of half adder

The simulation setup of all optical half adder is shown in Figure 2. Simulation is done using Optsim software. The data streams Data 1 at wavelength 1553.05 nm and data2 at wavelength 1557.75 nm are generated by the mode locked lasers (MLLaser1& MLLaser2). The output of the mode locked lasers i.e. soliton pulses are passed through a dispersion management block where they acquire the characteristics of dispersion managed soliton pulses. The dispersion managed soliton are modulated by an electrical PRBS (pseudo random binary sequence) generator.

The data is provided through the custom files by the user in PRBS generators. The twodata streams data 1 and data 2 are combined to generate single stream using an optical multiplexer (OptMux1).

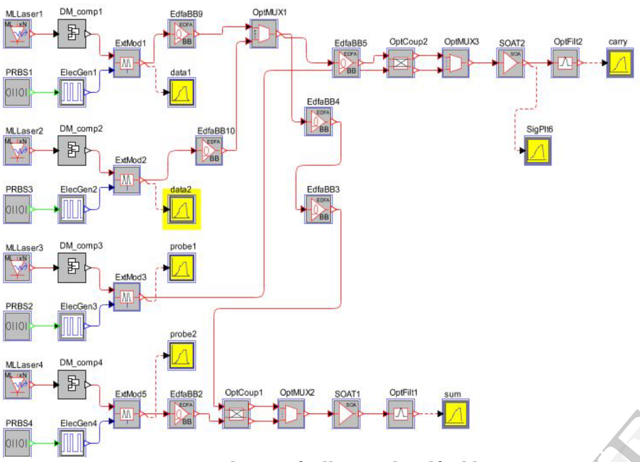

Figure 2:Simulation of All optical Half adder

For carry, the combined data is amplified using an EDFA amplifier. The probe signal of wavelength 1548.3nm is generated using another mode locked laser and a custom file of alternating 1's and 0's is given from probe 1, which is then amplified using EDFA.The combined data and probe data is introduced to optical coupler (OptCoup2) and then the combined data through multiplexer (OptMux2) is introduced to SOA2. XGM takes place inside SOA2 and gain of amplifier is modulated. An optical band pass filter (OptFilt2) with centre wavelength 1552nm and bandwidth 0.1nm is used to select the required spectrum of data streams. The resultant carry output is observed using signal analyzer carry [4].

For sum, The probe signal is generated by mode locked laser at wavelength 1548nm and a custom file of alternating 1's and 0's is given from probe 2, and then it is amplified using EDFA (EdfaBB2) and the combined data from optical multiplexer (OptMux1) is amplified by EDFA (EdfaBB4) and then through optical coupler (Optcoup1), is given to SOAT1. The optical filter (OptFilt1) is tuned at 1559 nm wavelength and 0.1 nm bandwidth to obtain the required spectrum. The resultant sum output is observed using signal analyzer Sum [5].

The design model for full adder contains AND, OR and XOR gate. Block diagram of all optical Full adder is shown in Figure 2. The setup consists of two XOR gates and two AND gates and one OR gate. Sum is generated using two XOR gates and Carry is generated by applying OR logic to two AND gates. For this purpose, Cross Gain Modulation which produces non-linear effect in SOA cavity is used. Three

high power control pulse (pump) and three low power probes are used. These control pulses are shot together with probes into SOA to realize different logic (XOR, AND, OR). For sum output, XOR logic is used and for carry AND and OR logic are used.

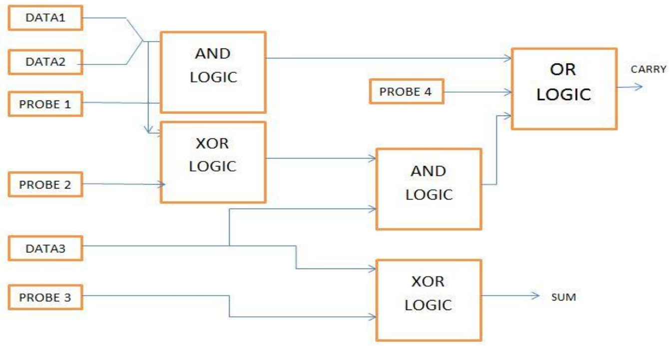

Figure 3: Block diagram of all optical full adder

Simulation setup for full adder is depicted in Figure 4. The data streams Data 1 at wavelength 1557.75nm, data 2 at wavelength 1557.75 nm and data 3 at wavelength 1557.75nm are generated by the mode locked lasers (ML laser1,ML laser2 and ML laser5). The output of the mode locked lasers i.e. soliton pulses are passed through a dispersion management block where they acquire the characteristics of dispersion managed soliton pulses. The dispersion managed soliton are modulated with the electrical PRBS data. The custom files are used to provide data through PRBS generators. The two data streams data 1 and data 2 are combined to generate single stream using an optical multiplexer (OptMux1) and then through probe given to compound component (and1-comp) which contains logic AND.

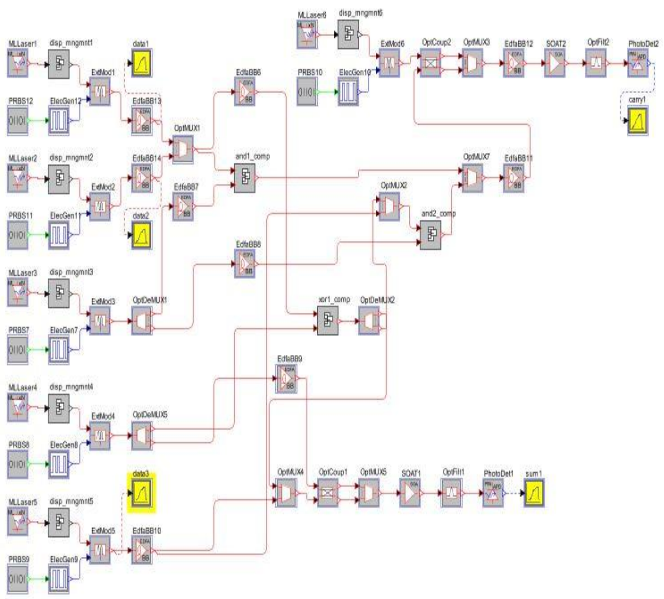

Figure 4: Simulation of all optical full adder

For generating sum, the probe signal from mode locked laser (ML laser4) at wavelength 1550 nm (alternating 0's and 1's) which is given to XOR logic compound component (xor1-comp), and then data 3 is amplified using EDFA (EdfaBB5). The combined data from Optical Multiplexer (OptMUX4) is amplified by EDFA and then through Optical coupler (OptCoup1), is given to SOA (SOAT1). Optical Filter (Optfilt1)is tuned at 1554nm wavelength and 0.1 nm bandwidth to obtain the required spectrum which is inside compound component xor1. The resultant sum output was observed using signal analyzer sum [5].

For carry, the data is combined by Optical Multiplexer (OptMUX7) through compound components having AND logic (and1-comp) and (and2-comp).Both of the components have Optical filters of wavelength 1490nm used for AND operation. An EDFA amplifier is used for amplification of weak signal. The probe signal of wavelength 1550nm is generated using another mode locked laser (ML laser6) are alternating 1's and 0's. The combined data and probe data is introduced to optical coupler (OptCoup2) and then the combined data through multiplexer (OptMUX3) is introduced to SOA (SOAT2). XGM takes place inside SOAT2 and gain of amplifier is modulated. An optical filter (OptFilt2) with centre wavelength 1548.5nm (the mean of wavelengths of data1, data2 & data3) and bandwidth 0.1nm is used to select the required spectrum of data streams. The resultant carry output is observed using signal analyzer carry [4].

III. RESULTS AND DISCUSSION

The input data streams of data1 and data2 are shown in Figure.5 and Figure.6 respectively. In half adder, the sum output is high when only one input is high and other input is low and carry output is high only if both inputs are high. In the proposed all-optical half adder, same output was confirmed as the output waveform of resultant signal i.e. sum as shown in figure 7 and carry as shown in figure 8.

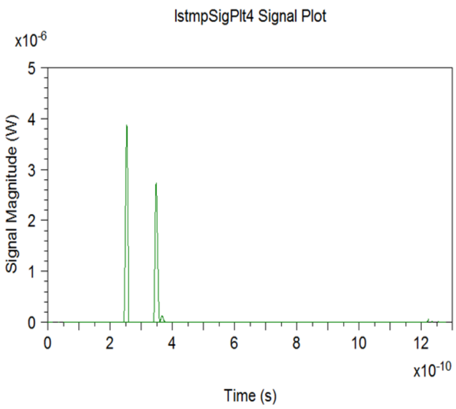

Figure 5: Input data 1

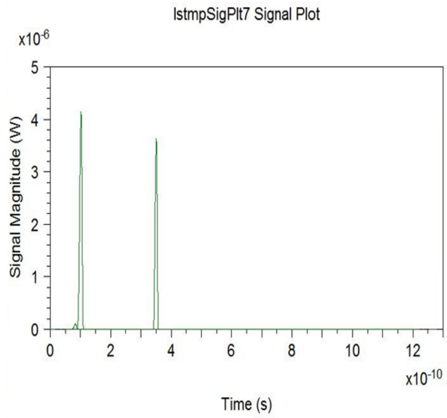

Figure 6: Input data 2

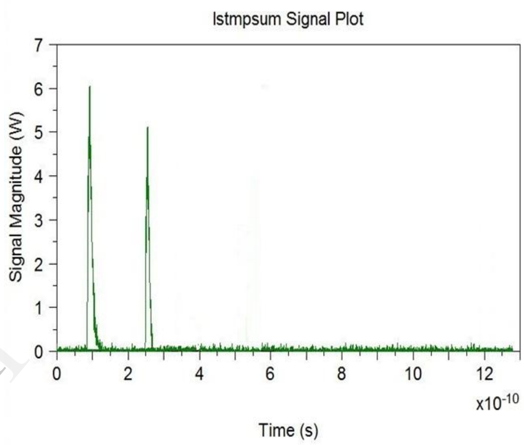

Figure 7: Half adder Sum

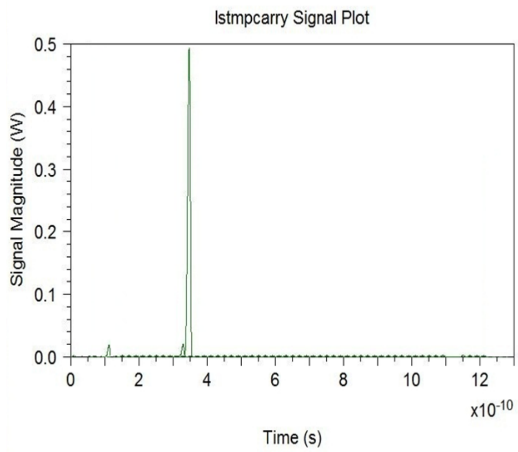

Figure 8: Half adder Carry

The input data streams of data1, data2 and data3 are shown in Figure 9, Figure 10 and Figure 11 respectively.The sum output is high when either one input is high or all the inputs are high and carry output is high only if any of two inputs are high or all inputs are high. In the proposed all-optical full adder, same output was confirmed as the output waveform of resultant signal i.e. sum as shown in figure 12 and carry as shown in figure 13.

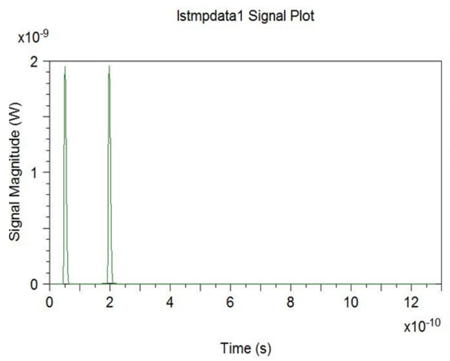

Figure 9: Input data 1

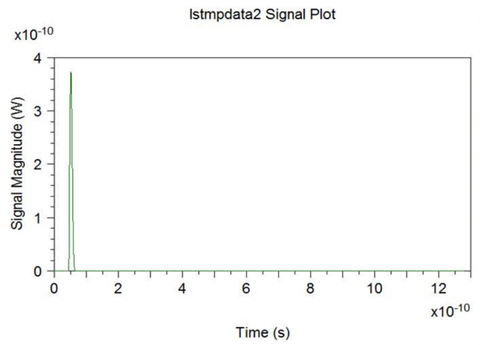

Figure 10: Input data 2

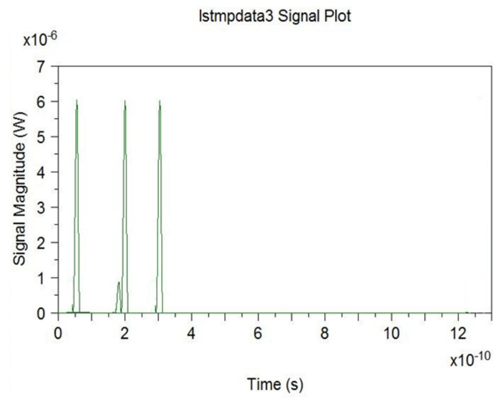

Figure 11:Input data 3

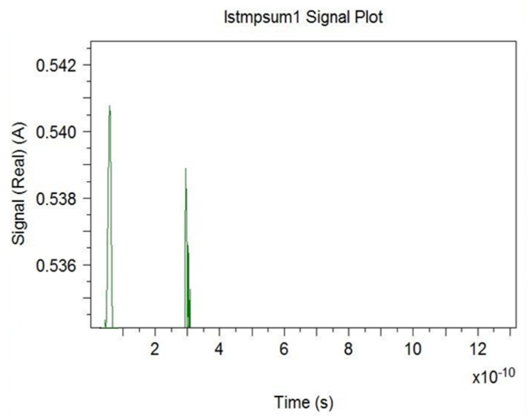

Figure 12 :Full adder sum

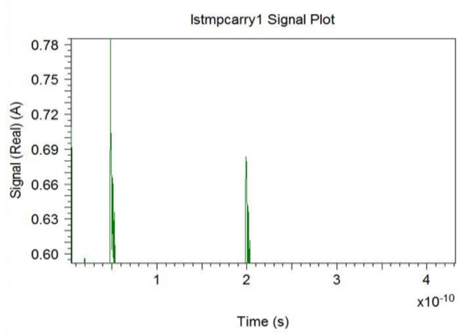

Figure 13: Full adder carry

IV.CONCLUSION

All optical full adder and Half adder were modelled using DM solitons as input pulses and utilizing nonlinear properties of SOA and XGM. Compared to other approaches that have been used for designing logic gates and all optical adders, the proposed design in this paper is a much simpler design and helps to achieve higher data rate processing.

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