Designing of All Optical XOR, AND, OR and NAND Gate based on Cross-Phase Modulation in HNLF

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Abstract: - **All optical XOR, AND, OR and NAND gates based on cross-phase modulation. It accomplishes error-free performance at 10 Gb/s and the receiver sensitivity presents for a bit-error rate of 10^{-9} is below -15.0 dBm. The designing parameters of these gates are more accurate and sensible if we utilize the non-linear characteristics of fiber like Cross gain modulation (XGM).**

Keywords- **optical logic, cross-phase modulation (XPM), highly nonlinear fiber (HNLF), all optical signal processing, optical communications.**

I. INTRODUCTION

Development of future telecommunication networks requires optical technologies such as multiplexers, synchronization of packet, clock recovery, and signal regeneration in order to avoid conversion from optical to electrical. High-speed all-optical logic gates are basic elements to realize all-optical functions.

From many of the nonlinear materials are researched only one has materialize as a practical explanation for all optical signal processing is semiconductor optical amplifier (SOA)[1]. All optical signal processing is particularly of interest telecommunications applications, the cross phase modulation (XPM) is simple to implement and high bit rate operation can obtained, with high conversion efficiency and as well as insensitivity to the polarization of input signal.

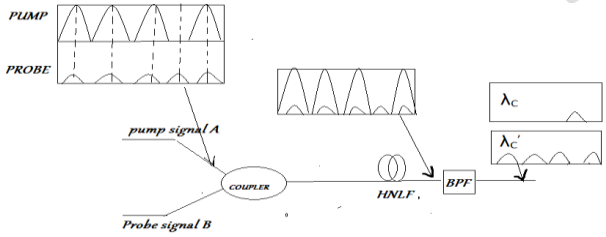

Fig. 1. Shown the principle of operation of the gate: input signal waveforms and output waveform which associated with the probe signal

It proposed a simple multilogic XOR, AND, OR and NAND gate based on cross-phase modulation (XPM) in an HNLF . It realized logic operations at 10 Gb/s using on a single device under the same input operating conditions. The reconfigurability between the various logic operations was achieved solely by adjusting the center wavelength of the band pass filters (BPFs) [3].. However, it did not achieve error-free operation in [3]. So now we have since modified our setup and in this letter and report error-free operation and bit-error-rate (BER).

Two signals return-to-zero, on–off keying (RZ-OOK) is implemented and both synchronized signals 10-Gb/s signals containing picosecond pulses are sent into a length of HNLF. Because it only use one nonlinear effect (i.e., XPM)[4], the experiment is very simple easy to design and control. Moreover, it have used two input data signals, hence it can avoid the need for additional sources such as a continuous-wave (CW)[5] or a clock signal. However, it did not achieve error-free operation..

II. DESIGN & SIMULATION OF ALL OPTICAL GATE

In this paper the two synchronized signals, signal A and B comprising picosecond pulses are launched into a length of HNLF. Signal A has higher power works as a pump[5] called pump signal and signal B has a lower power works as a probe called probe signal. After passing through HNLF, the spectrum of probe B experiences an XPM-induced frequency shift which is proportional to the slope of the power profile of the pump signal[6].

The HNLF has a length of 1007m nonlinearity coefficient of 12.5 W^{-1} km^{-1} , chromatic dispersion of 0.69 ps/nm km at wavelength 1550.0 nm, and dispersion slope of 0.0074 ps/nm km at wavelength 1550.0 nm

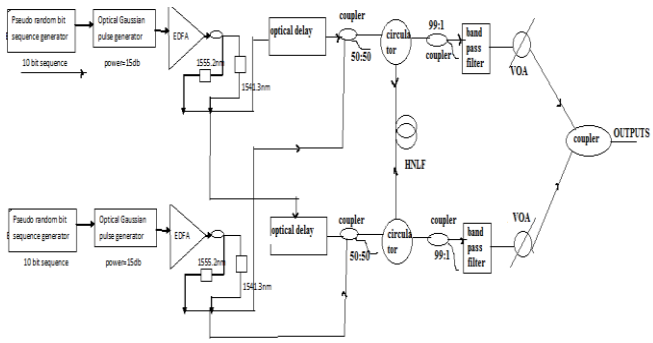

Fig:-2 layout of experimental set-up

A CW laser and the output of XOR gate is used to demonstrate optical gate shown in fig.-2. two data pump and

probe generators (transmitters A & B) for one signal and then combined with another two transmitter(C & D).

Table 1
Shows wavelength of various gates

λ_A =1555.24nm, λ_B =1541.32nm		
Logic	λ_{BPF2}	λ_{BPF1}
XOR	1541.40nm	1555.08nm
AND	1538.32nm	1558.52nm
OR	1541.32nm	1555.08nm

It have been used to get desired output. The circuit consists of two optical XOR gate and combined at third coupler.

The output of optical NAND gate is HIGH=1 when both the XOR outputs are A=0,B=0 or when alternatively A=1,B=0 OR A=0,B=1 and the output of optical NAND gate is LOW=0 when A=1,B=1

III. EXPERIMENT AND RESULTS

This experiment is setup which uses commonly and it is suitable fiber pigtailed components. The Highly nonlinear fiber is used for the length of 1007 m, the nonlinearity coefficient of 12.5 W^{-1} km^{1}, to be chromatic dispersion 0.69 ps/nm km wavelength at 1550.0 nm, and dispersion slope 0.0074 ps/nm km at 1550.0 nm. The two signals (A and B) comprising pulses and for another two signal (C and D) with a full-width at half-maximum pulse width of the valve of 3.1 ps are generated by two tunable mode-locked lasers modulated and similarly for another signals by a 2^7-1 PRBS using the two independent LiNBO modulators. The center wavelengths of the signals A and B are 1555.2 and 1541.3 nm , respectively. And for other two signals C and D are 1555.2 and 1541.3nm. After amplification, the signals A and B are to be divided into two parts properly separated paths by the two 95/5 couplers and then subsequently recombined by using two 50/50 couplers. 95% of power from the signal A (acting as pump with the power of 17.2 dBm) and the 5% of the power from signal B (acting as probe with a power of 3.0 dBm) propagate *downwardly* and through the HNLF via an optical circulator (OC1) and the another same as, 5% of the power from the signal A is acting as a probe with the power of 3.3 dbm and 95% power from the signal B (act as pump with the power of 17.6 dBm) propagate *upwardly* through the highly nonlinear fiber through another circulator (OC2). The optical delay lines (ODLs) which is variable and the polarization controllers (PCs) between the 95/5 couplers and 50/50 couplers both are used for synchronization purposes. to maximize XPM(cross phase modulation), respectively. After passing through BPF1 and BPF2, the third ODL (The optical delay lines) and a variable optical attenuator (VOA) both are used to synchronize the following pulses and as well as equalize their power before recombined. By adjusting the center wavelengths of BPF1 and BPF2, and respectively BPF3 and BPF4 results are achieved without changing the input variables (e.g., power, wavelength, and polarization).

For XOR gate:-

When both inputs are different, the output is 1 otherwise 0

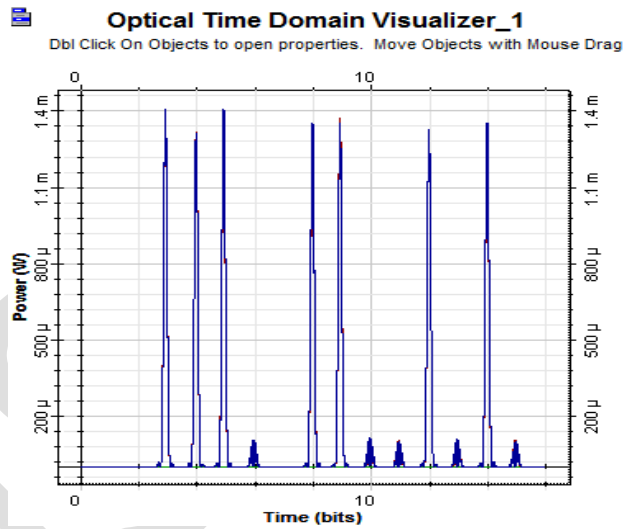

Fig 3:- Result of XOR gate when both inputs are same the output will be 0 otherwise 1

For AND gate:-

In and gate it performs multiply operation so that it gives 1 only for condition, if both the inputs are 1 otherwise 0.

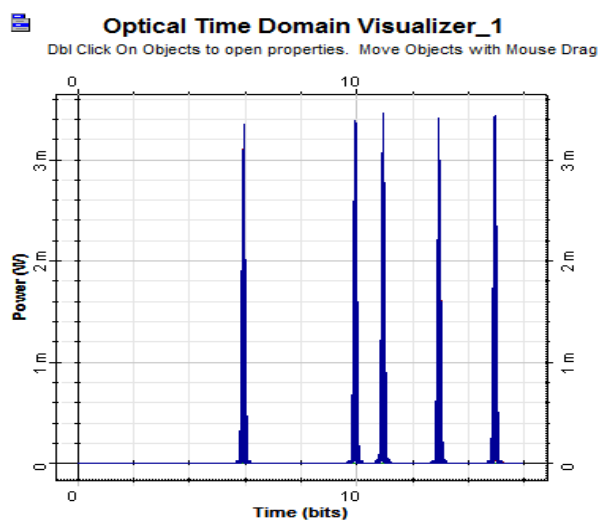

Fig 4 :- Result of AND gate it performs multiply operation

For OR gate:

As we all know OR gate performs addition operation it remains 1 foer all the time but it generates carry bit.

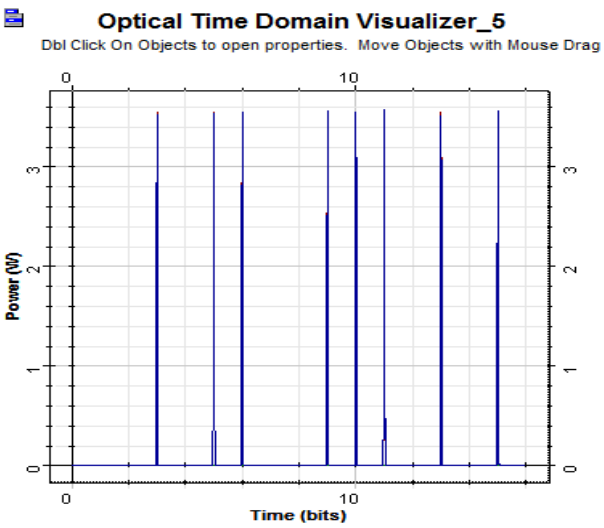

Fig 5 : Result of OR gate it performs addition operation

For NAND operation:-

It shows the input and outputs in table 2

Table 2
Inputs and outputs of NAND gate

S.No	Input 1	Input 2	NAND LOGIC
1	0	0	1
2	0	1	1
3	1	0	1
4	1	1	0

When both the inputs are 0, the output will be 1

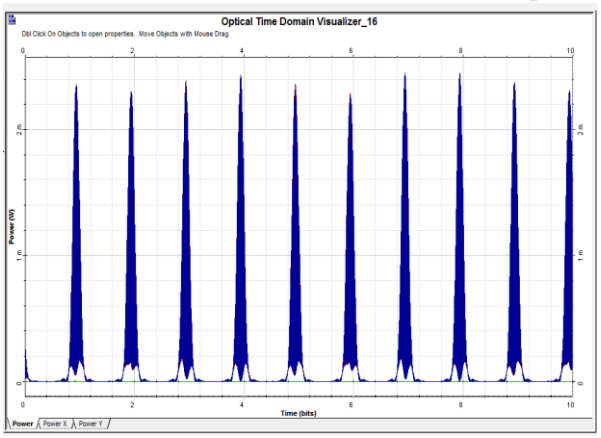

Fig 6:- Result shows when both the inputs are 0 the output will be 1.

When both the inputs are 1, the output will be 0.

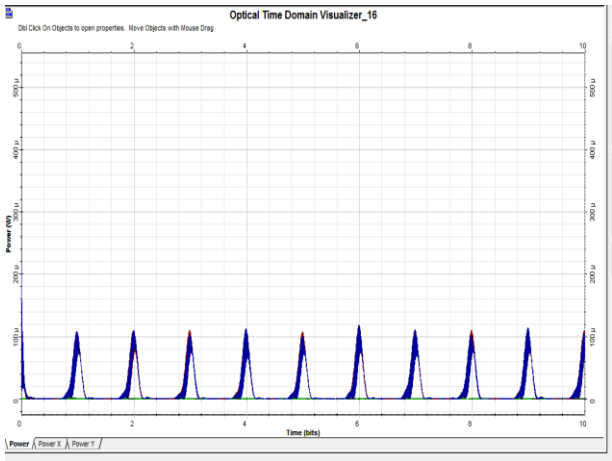

Fig 7:- Result shows when both the inputs are 1 the output will be 0.

For output power calculation time domain visualizer and power meter is used for different combination of input sequences When both the inputs are applied to coupler and add together it gives the output $\bar{A}$ $+\bar{C}$. and the final output gives as NAND gate output.

IV. CONCLUSION

We demonstrate a novel reconfigurable all-optical multilogic (XOR, AND, and OR) device operating at 10 Gbps. Reconfigurability is achieved by changing centre frequency of Band Pass filter for a single structure. Here we do not need to change the configuration for each logic gate (XOR, AND and OR). We can also modify this configuration for half adder (HA) and half subtractor (HS). By using same principle we can also design NAND gate.

The logic gate has a very simple structure which uses a single HNLF without any additional input such as a CW or clock.
This system can also be design for higher than 10Gbps. As we increase the speed it introduces some dispersion and by using proper dispersion compensation technique & nonlinear parameter it can be remove.

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