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All Optical SOA-MZI Based Encryption and Decryption System using XOR gate

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ABSTRACT: All Optical logic gates are the building blocks of Optical signal processing devices. Due to the widely accepted quality of non-linearity in Semiconductor Optical Amplifier (SOA), it has made the finest attractive source for the actualization of all logic gates in optical networks. Ultrafast all optical XOR gate is realized and analysed based on the SOA nonlinearity and the detuning optical band pass filter using Cross phase Modulation (XPM). Optical encryption and decryption system is successfully demonstrated using Cross Phase Modulation of Semiconductor Optical Amplifier using XOR gate. The design and simulation of all optical XOR gate and its application in optical domain can be described with the help of OptiSystem software

KEYWORDS: All Optical Logic Gates, Mach-Zehnder interferometer (MZI), Cross Phase ModulationNonlinear Optical effects,Semiconductor Optical Amplifier (SOA).

I.INTRODUCTION

The need for high bit rate circuit is increasing day by day. Inorder to overcome the bit rate limitations caused by electronic signal processing all optical signal processing is required. Optical processing deals with realising digital circuits using optical elements only. All- Optical processing is a swarming field of research in present day optical networks. It is a light based circuits that is capable of performing signal processing operation at ultra-high speed compared to electronic counterparts. In optical computing switching, arithmetic operations and storage are the basic functions [2]. As the speed of telecommunication systems increases and reaches the limit of electronics devices, demands for digital all optical operations, such as switching, decision making ,regeneration, and basic or complex computing, are rapidly increasing. XOR logic gates operate as data encryption and decryption system .In this work, demonstrated all optical encryption and decryption systems using XGM characteristics of SOAs.

The continuous expansion of optical networks, the need for securing the information flow through the networks is inevitable. To secure the data while transmission, various encryption techniques have been proposed. Most of the proposed encryptionsystem becomes very difficult at high bit rates and also which require optoelectronic conversion. Here a new technique based on all optical XOR gate as the building block of all optical encryption system with SOA-MZI structures. SOA possesses nonlinearity effects likes Cross Phase Modulation (XPM), Cross Gain Modulation (XGM), and Four Wave Mixing (FWM). SOA also have a wide gain spectrum, low power consumption, monolithic integration with other devices, and low cost. Because of these advantages, SOA have been widely used as a nonlinear element for optical processing and optical computing for the next generation secure optical networks.

II.SYSTEM MODELLING

To perform the XOR Boolean function two optical beam carried by the optical signal at the same or different wavelengths are sent through the port 1 and port 2 of the MZI separately. The wavelength of the two data signal can also be the same. A train of pulse or CW beam is coupled to port 3 as the control signal. The control signal splits into two equal parts, one reaching the upper branch of the interferometer and the other reaching the lower branch. When data signal (bit sequence to be compared) is launched into the SOAs, the carrier density and thereby, the medium refractive index is modulated. This causes the phase shift over the control signal counter- propagating through the SOAs (control signal) according to the intensity variation of the input data signals.[1].

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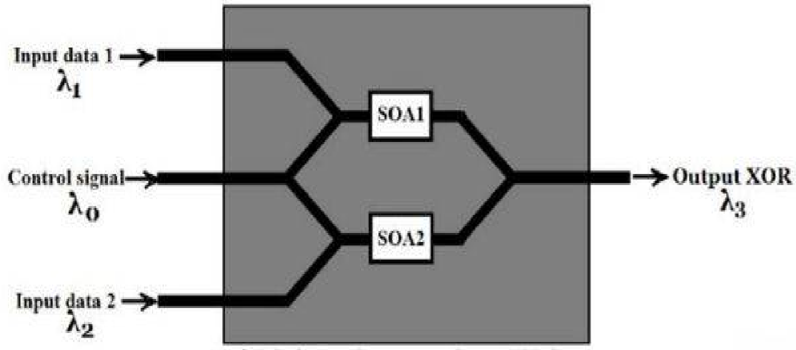

Fig. 1 SOA-MZI used as an XOR gate.

The control signal entering port3 split into two equal parts, one reaches the upper branch of the interferometer and other reaches the lower branch, initially the MZI is balanced, because phase shift between both the arms is same. The XOR gate, gives a “1” at the output if one, and only one of the two inputs is a “1”. More generally, an XOR gate with an arbitrary number of the input gives a “1” at the output if the parity of the input bits is “1”, i.e., the number of “1” is odd [1]. This property of the XOR gate makes it suitable for a wide variety of applications related to bit-comparison and encryption. SOA-MZI used as an optical XOR gate as shown in fig: 1.

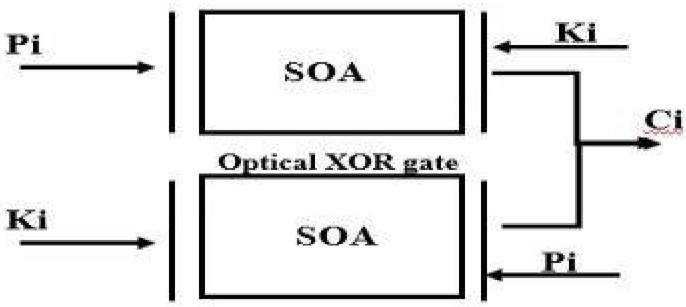

Fig. 2 Proposed SOA based Encryption system

The brief schematics of experimental setup for all optical encryption and decryption system using XOR logic gate is shown in fig 2. Our proposed encryption system is based on XPM effect. Intensity modulated data signals influence the number of carriers in the SOA, which in turn affect the gain and refractive index of SOA, which results in phase modulation of continuous wave signal. The data signal is denoted by Pi (plaintext), which is generated by a user defined bit sequence generator. Security key, denoted by Ki is generated by another user defined bit sequence generator. Both Pi and Ki is launched into the two arms of the wideband travelling wave SOA with MZI where XPM occurs. Encryption process is achieved through all optical XOR logic using SOA. An encrypted signal, Ci can be explained in the equation Ci= Pi XORKi[2].

Decryption of encrypted data can be achieved with XOR logic operation of Ci and Ki, i.e.,[3]

Pi =CiXOR Ki

= (Pi XOR Ki) XOR Ki

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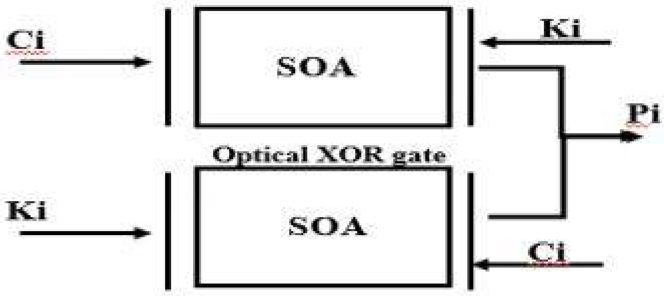


Fig. 3. Proposed SOA based Decryption system.

The encrypted signal Ci and Ki are applied to two inputs of wideband travelling SOA-MZI. Fig 3 clearly shows that our transmitter section performs XOR operation to generate encrypted signal Pi XOR Ki=Ci. Plaintext signal Pi can be recovered from receiver section by performing XOR operation between Ki and Ci(Pi XOR Ki).[4]

III. SIMULATION SETUP

The simulation setup of proposed all optical XOR system is based on optisystem software version 12 as shown in fig 4. Here user defined bit sequence generator is used for input data sequence. A continuous wave signal is used for enabling the SOA-MZI switching structures. If A=1 and B=1 AND control signal is present, both the arms of the SOA-MZI structures enables , due to XPM refractive index of the medium changes, phase shift produced in the both arms is same. So output obtained is zero. If the input A=1 and B=0 and control signal is present. At this point, optical pulses enter the SOA-MZI through port 1 and change the refractive index of the upper SOA whereas lower SOA remains unaffected. The same phenomenon happens if A=0 and B=1.

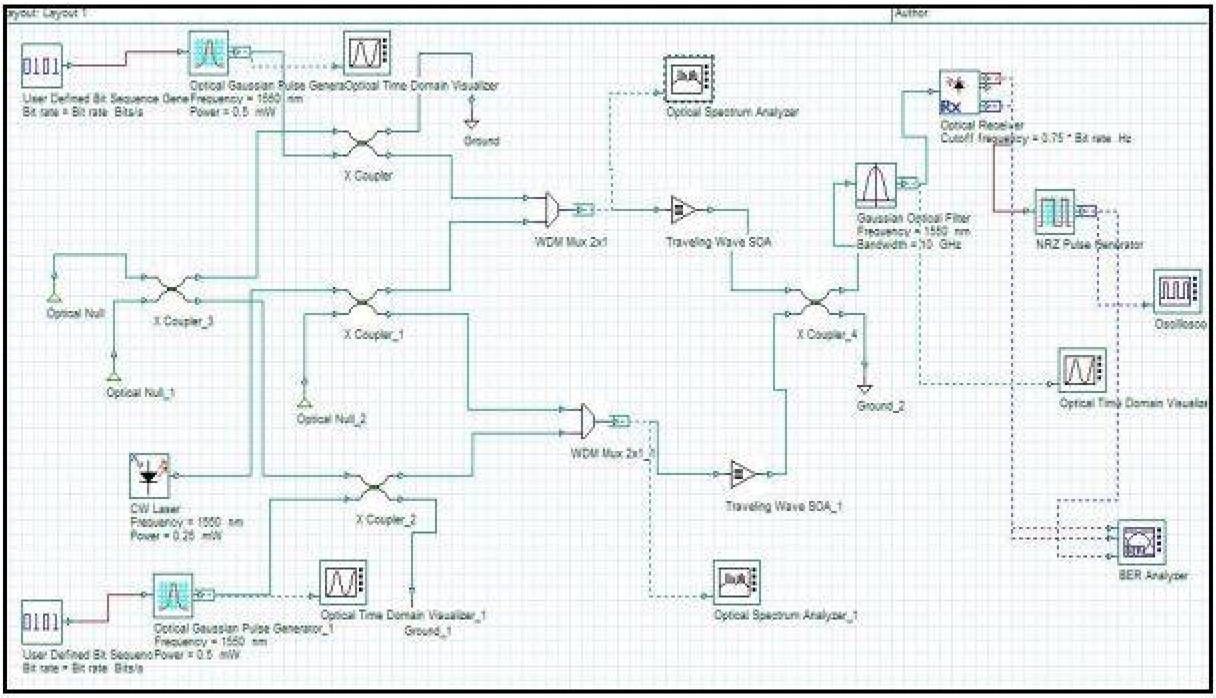


Fig. 4 Simulation setup of optical XOR gate using SOA-MZI.

The simulation setup of proposed optical encryption and decryption system using OptiSystem version 12 is shown in fig 5. In encryption part, signal Pi as a probe beam and signal Ki as a Pump beam in SOA- 1.Signal Ki as a probe beam and signal Pi as a pump beam in SOA-2. In decryption part, Ci and Ki signal is used as probe and pump beam and Pi signal is obtained by optical XOR logic operation.

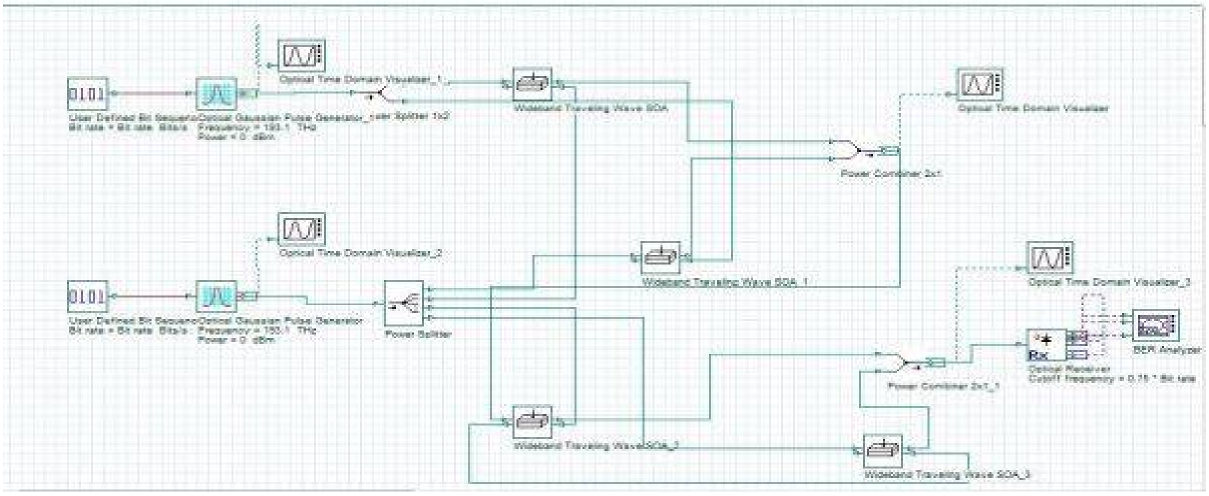
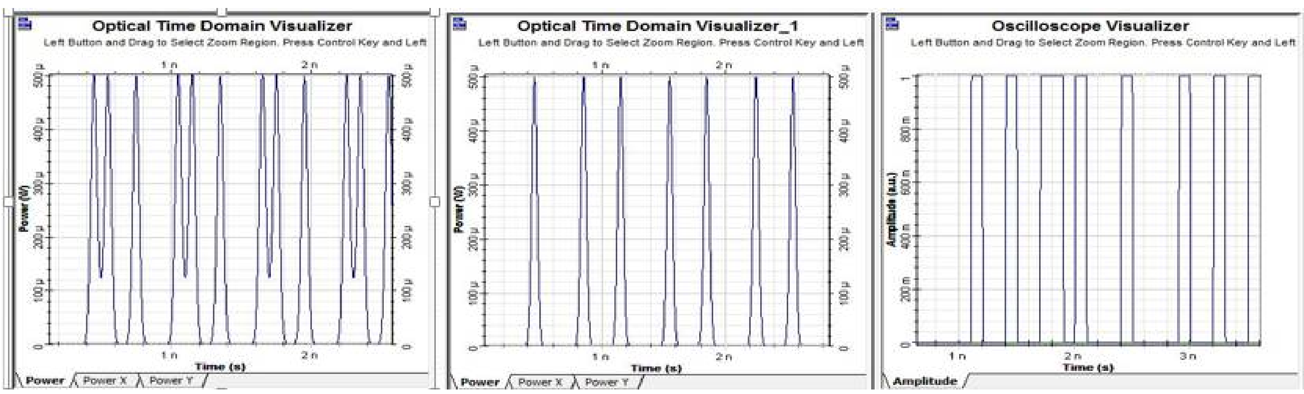


Fig. 5 Simulation setup of optical encryption and decryption system.

IV. RESULTS AND DISCUSSIONS

In XOR logic, high value is only when only one of the input signals are high. When both the signals are high, the output is low. In the simulation results it was observed that logic high pulses are obtained but when one of the data signals are high and low is obtained when both signals are high or low.



(a) (b) (c)

Fig. 6(a), (b) Input of XOR gate. (c) Output of XOR gate.

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An open eye pattern corresponds to minimal signal distortion. Distortion of the signal waveform appears as closure of the eye pattern. Fig 7 shows the eye diagram of optical XOR gate. Eye diagram of optical XOR gate having quality factor is about 10e50 and minimum Bit Error Rate is 0.

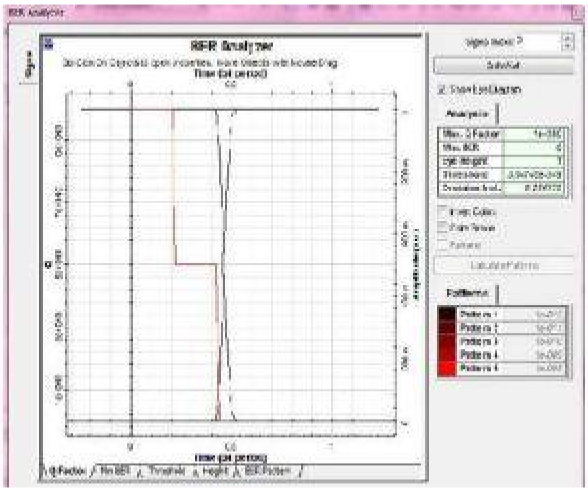
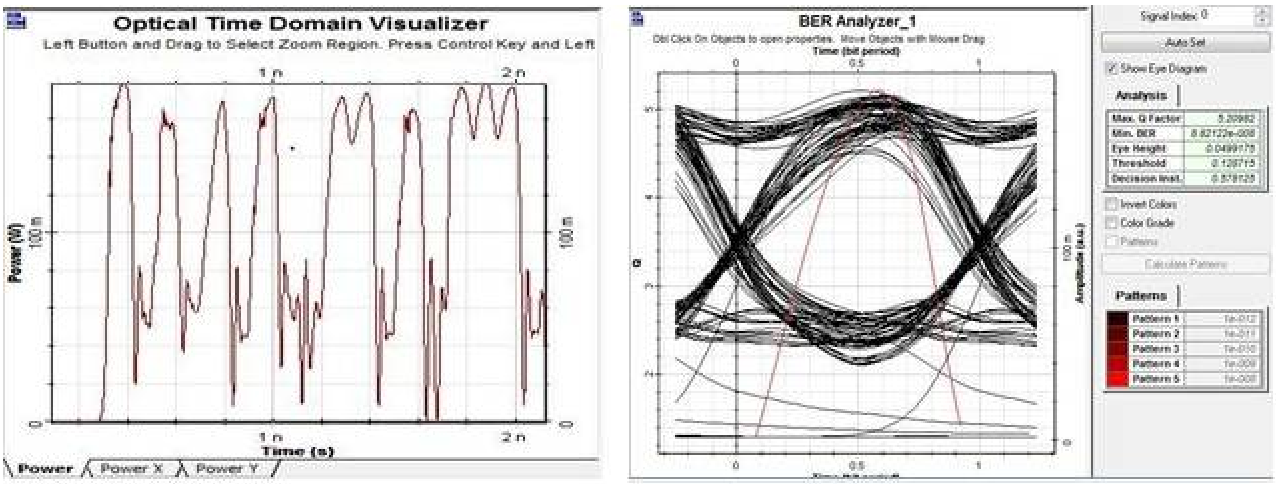


Fig. 7 Eye diagram of optical XOR gate.

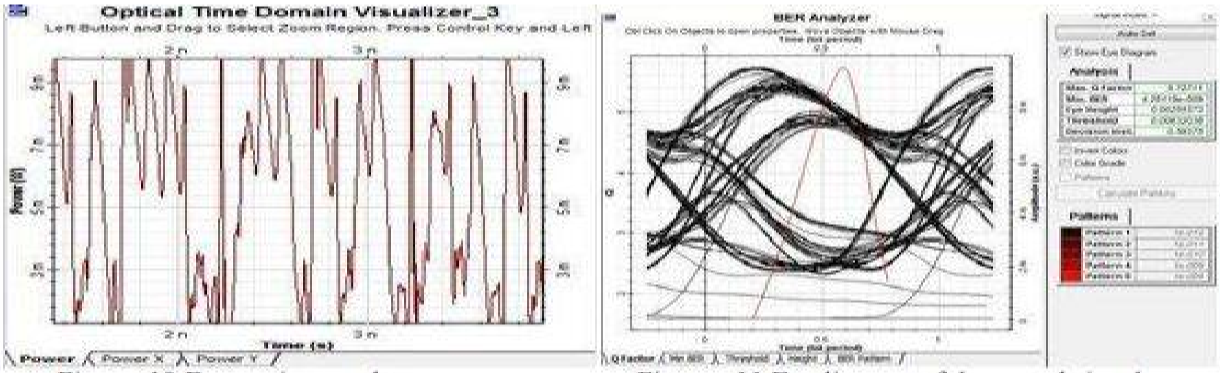
This section analysis the proposed encryption and decryption system. SOA parameter and constructional features of proposed XOR logic to successively decrypt original signal. Fig 8(a)and (b) shows the encryption operation of signal Pi and Ki and the eyediagram of encrypted signal. Encrypted signal have Q factor of more than 5.2897 with minimum BER.



(a) (b)

Fig. 8 (a) Encryption result of signal Pi and Ki (b) Eyediagram of encrypted signal.

In fig 9(a) shows the output of decrypted signal, which is same as that of the input signal Pi. The Q factor of decrypted signal is exactly same as that of the encrypted signal and also more than 5.7272, which is improved results over ref[4] with minimum BER which is shown in fig 9(b).



(a) (b)

Fig. 9 (a) Decryption result (b) Eyediagram of decrypted signal.

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VI.CONCLUSION

All optical logic gates are the building blocks of optical signal processing devices. A novel approach for all optical XOR gate can be realized using nonlinear characteristics of Semiconductor Optical Amplifier (SOA) with Mach-Zehnder Interferometer (MZI) and band pass filter. The implementation of SOA-MZI based XOR logic gate in the presence of CW beam is simulated for secure data transmission in optical fiber networks. The result also shows that there is no deterioration in the decrypted signal. This new approach offers compact, low latency and low power penalty to secure data transmission in optical fiber network.

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BIOGRAPHY

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