

Comparison between Optical XOR Gate with and Without Additional Input Beam

¹Bhupesh Chandra Kushwaha, ²Reena Kumari Jain

¹Student, Electronics and Communication Department, Secs, Rajasthan, India

²Assistant Professor, Electronics and Communication Department, Secs, Rajasthan, India

Abstract: Here in this paper we have compared the optical EXOR gate with additional input beam and without additional input beam using the two nonlinearity property XGM and XPM of SOA. CW Laser or clock signal is used as additional input beam. The extinction ratio of EXOR gate with additional input beam is 39.127 dB and the extinction ratio of EXOR gate without additional input beam is 11 dB, both are operated at 10 GB/s.

Keywords: Cross gain modulation, Cross phase modulation, semiconductor optical amplifier, Continuous wave laser

1. Introduction

As the speed of telecommunication systems increases and reaches the limit of electronic devices. Since, most of the optical materials are linear and allow light beams to pass through unaltered. So a non linear optical material in which different light rays can interact is the utmost requirement to achieve the all optical processing functions. Many researchers have reported various scheme that are XOR by using ultrafast nonlinear interferometer (UNI) [1], XOR by using terahertz optical asymmetric demultiplexer (TOAD) [2], XOR by using interferometric wavelength converter (IWC) [3] and XOR without using any additional input beam [4]. The Semiconductor optical amplifier (SOA) among many non linear material examined has evolved as a feasible solution for all-optical signal processing. In telecommunication, optical signal processing approach is of utmost importance to meet up the crucial requirement of speed, power and cost. Now a days telecom networks are based completely on electronic data handling, but the core network data speeds are at 40 Gb/s (40 billion bits per second) [5], and, instead of the cheap complementary metal oxide semiconductor (CMOS) silicon devices that earlier used to handled these signals, specialist electronic materials and advanced radio- frequency techniques are desirable. It is also very intricate to process and transmit electrical signals at these speeds, that require more power and cost.

So as to satisfy the ever-increasing demand of information communication for future optical networks, high speed digital processing is needed. Photonics signal elaboration at the optical layer is enticing to perform various computational functionalities, like bit-length conversions, switching, packet buffering, retiming and reshaping, header processing, and overcoming all the speed electronics limitations. In recent years, lots of effort has been spent in these fields and all-optical digital processing appears to be one among the foremost promising technologies to bring magnified capacity, flexibility, and scalability to ensuring next generation systems within the optical domain.

In advance digital communication, XOR gate play a vital role in Pseudorandom sequence generator, scrambling etc.

In this paper we made a comparison between optical XOR gate with and without additional input beam with respect to their extinction ratio. Here both are operated at 10 Gb/s and using the non linearity of SOA i.e. cross gain modulation and cross phase modulation. The both XOR gate that is proposed here is implemented by the cross gain modulation(XGM) occurs due to gain saturation in SOA.

2. Design of EXOR Gate Without Additional Input Beam

The schematic diagram used for simulation of all-optical XOR gate without additional input beam is shown in Fig. 1.

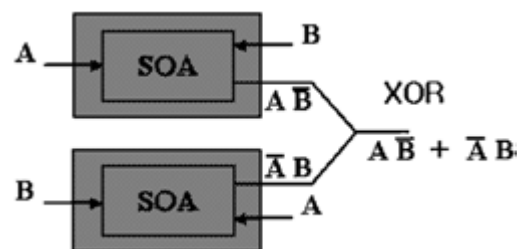


Figure 1

The structure of the proposed all-optical XOR gate is shown in Fig. 1. In the upper SOA, a probe beam A cannot pass through it when a strong pump beam B saturates its gain, while probe beam A simply passes through it in the absence of the strong pump beam B. Thus probe beam A passes through the SOA only if the pump beam B is absent, and thus Boolean is obtained as the output signal. In the lower SOA, A and B change their role and the output is given by Boolean. Combining the two outputs of the SOAs, we obtain Boolean, which is Boolean logically equal to A XOR B yielding the complete all-optical XOR gate operation. The proposed XOR gate looks very similar to the XOR gates based on Michelson interferometer, which utilize interferometric effects of two signals out of two SOAs [6]. However, the basic operation principle is totally different since logic XOR operation in this experiment is based on the gain saturation effect by XGM in SOAs [7]. Moreover, additional beams like a clock signal or CW light, required for most of other XOR gates, are not used in this XOR gate. In addition, the XOR gate is inherently polarization independent if the SOAs have no polarization dependence.

3. Simulation Circuit of Optical EXOR Gate Without Additional Input Beam

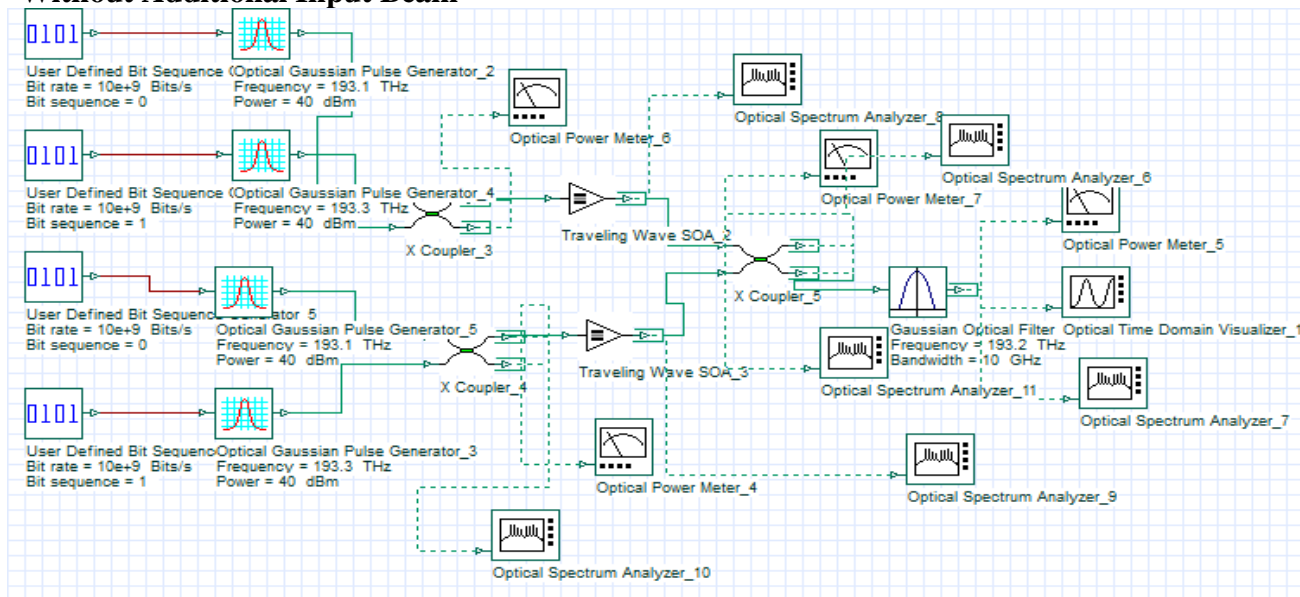


Figure 2: Circuit of optical EXOR gate without additional input beam designed on Opt wave Software

4. Design of EXOR Gate Without Additional Input Beam

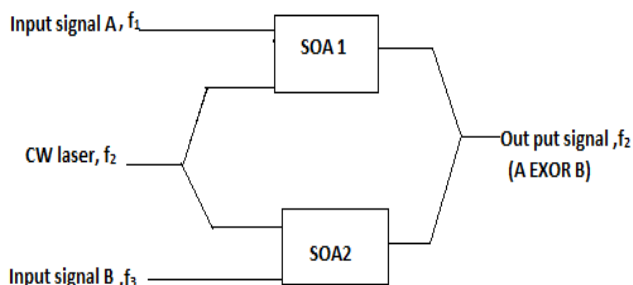


Figure 3: Configuration of all-optical XOR gate with additional input beam.[4]

This design is using phase to amplitude modulation in semiconductor optical amplifier co propagating Mach-Zehnder interferometer (SOA-MZI) configuration. In this XOR gate,

CW laser beam is used as additional input beam. A works on all optical combinational circuits based on SOA in filter configuration are reported in research papers [6,8] . SOA-MZI configuration [9] is superior to optimize the performance of all-optical logic gates. Therefore SOA-MZI configuration is used for the design of all-optical XOR gate used in the proposed all-optical encoders.

So, the output of XOR gate is calculated by equation given below:

$$G_n = A_n \oplus B_n, \text{ where } n = 0, 1, 2, \dots$$

5. Simulation Circuit of Optical EXOR Gate with Additional Input Beam

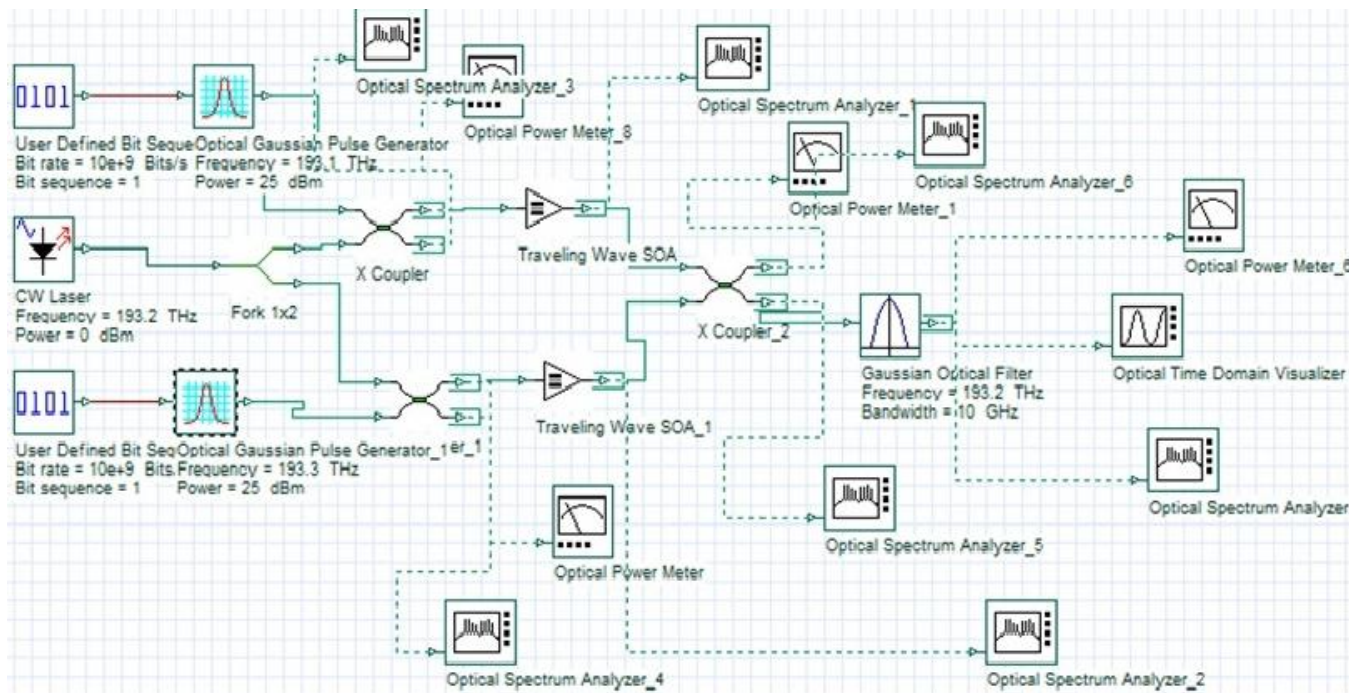


Figure 4: Circuit of optical EXOR gate with additional input beam designed on Optiwave Software

6. Simulation Result of Optical EXOR Gate

Boolean expression: $AB + \bar{A}\bar{B} = A \text{ XOR } B$

Table 1: Truth Table of optical EXOR gate

A	B	XOR
0	0	0
0	1	1
1	0	1
1	1	0

7. Comparison Between both Optical XOR Gate with and Without Additional Input Beam

“All-optical XOR gate using semiconductor optical amplifiers without additional input beam,” presented by J. H. Kim, Y. M. Jhon, Y. T. Byun, S. Lee, D. H.Woo, and S. H. Kim [4], proposed design of an all-optical XOR gate by using cross-gain modulation of semiconductor optical amplifiers has been suggested and demonstrated successfully at 10 Gb/s. No additional input beam such as a clock signal or continuous wave light is used in this design. The extinction ratio of this XOR gate was measured to be 11db.

While in the design of “All-optical XOR gate using semiconductor optical amplifiers with additional input beam” using phase to amplitude modulation in semiconductor optical amplifier co propagating Mach-Zehnder interferometer (SOA-MZI) configuration. . Additional input beam such as a clock signal or continuous wave light is used in this design. The extinction ratio of this XOR gate was measured to be 39.127 db.

8. Conclusion

So, optical XOR gate using semiconductor optical amplifiers with additional input beam has better extinction ratio than optical XOR gate without additional input beam. XOR gate with additional input beam provides extinction ratio of 39.127 db which is a better extinction ratio so as to differentiate easily between low and high logic levels in terms of power. The MZI co-propagating configuration used in XOR gate with CW laser beam is superior than other designs reported earlier as it provide high operating speed and good extinction ratio. This paper will provide the better optical XOR gate on the basis of extinction ratio. On the basis of this criteria , different logic circuits such as Pseudorandom sequence generator, scrambling, encoders etc can be designed in all-optical domain.

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