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Optical Gray to Binary Code Converter with and Without Mach-Zehnder Interferometer

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Abstract: *This paper is all about the techniques which we can use to reduce attenuation, improve power and to increase speed in optical communication. Here we are going to design optical gray to binary code converter by two techniques, first by using travelling wave SOA and second by using MZI (Mach-Zehnder Interferometer). Comparison of these two techniques is also done in terms of extinction ratio and outputs. All circuits are implemented successfully at 10 GB/s with the help of OptiSystem software.*

Keywords — Optical communication, Semiconductor Optical Amplifier (SOA), Mach-Zehnder Interferometer (MZI), Gray Code, Binary Code.

I. INTRODUCTION

In digital communication most important is to minimize the complexity and this can be achieved by taking all devices and networks in optical form. All-optical logic gates become key elements in optical communication. By using cross-gain modulation and cross-phase modulation in semiconductor optical amplifier, many logic functions of logic AND, OR, XOR, NOR and XNOR were demonstrated [1-2]. And there is one more technique to design all optical logic gates which have ultra-fast speed and less attenuation, using semiconductor optical amplifier based mach-zehnder interferometer [3-5]. With the help of all-optical gates optical amplifiers it becomes easy to design different kind of optical networks without conversion of optical signals to electrical signals or vice-versa. For the designing of optical gray to binary code converter there is need to design all-optical XOR gate first. Gray code is a unit distance code. It is a non-weighted code because position of code is not assigned a fixed value. There are many applications in which there is need of gray to binary code converters and in optical communication it is more significant to use it.

II. SOA BASED

A. Basics

The XOR gate has a special interest since it is the main building block for a wide range of functions. The principal on which gray to binary code converter work is given by-

The most significant bit of the binary code is same as the most significant bit of the gray code.

N^{th} bit of binary = N^{th} bit of gray XOR $(N - 1)^{th}$ bit of binary. For 4-bit gray to binary code converter which consist of G_0, G_1, G_2, G_3 gray bits and B_0, B_1, B_2, B_3 binary bits as shown in Fig. 1, we are going to use the SOA based simulated designing of optical XOR gate as shown in Fig. 2. Here we are using software named as OptiSystem for the designing of various optical networks.

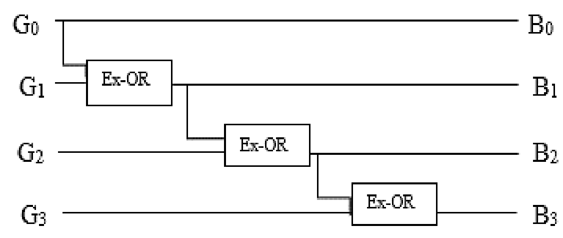

Fig. 1 4-Bit Gray to Binary Code Converter

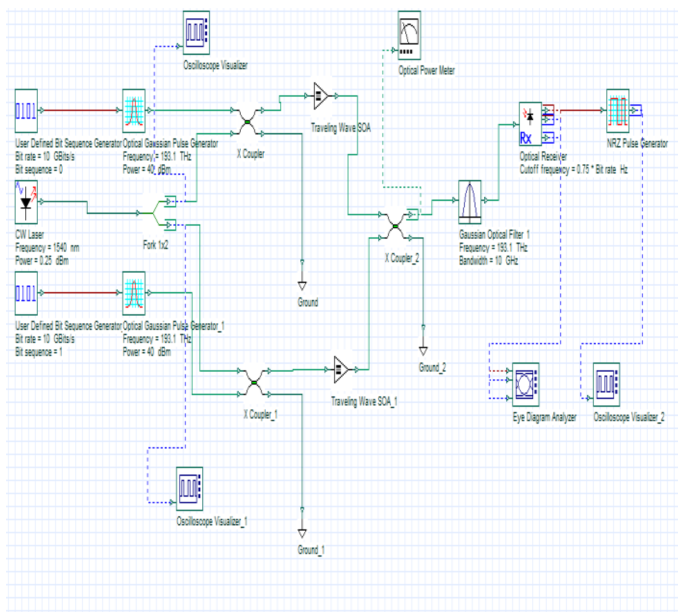

Fig. 2 Simulation setup of SOA based XOR gate

III. SOA-MZI BASED

SOA-MZI based XOR gate seems an easy solution to achieve the integration level required for complex logic circuits due to its compactness and stable structure. It provides less attenuation, high accuracy and high excitation ratio as compare to SOA based XOR gate. Simulation setup of SOA-MZI based optical XOR gate is shown in Fig. 3.

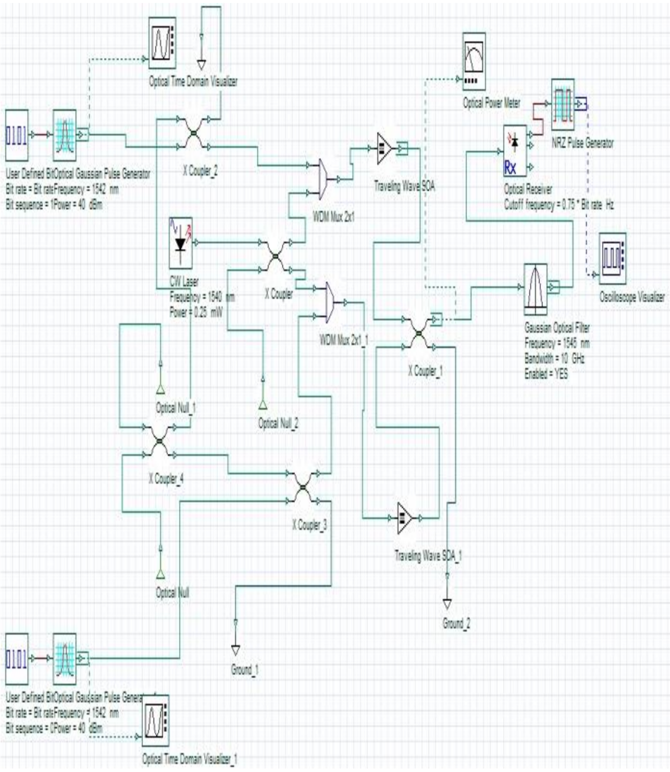

Fig. 3 Simulation setup of SOA-MZI based XOR gate

IV. COMPARISION

A. Simulation

Circuit of optical gray to binary code converter designed on Optisystem software is shown in Fig. 4. For 4-bit gray to binary code converter three Ex-OR gate subsystems are used. Power meters are connected for getting output in terms of power.

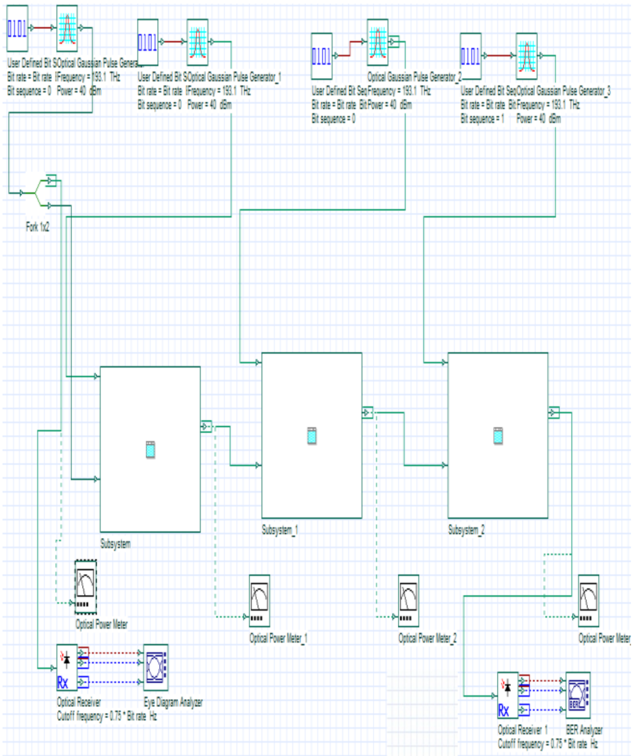

Fig.4 Simulation setup of gray to binary code converter

B. Simulated results

For gray code 0010 (G_0=0, G_1=0, G_2=1, G_3=0) as input we are getting binary code 0011 (B_0=0, B_1=0, B_2=1, B_3=1) as output. With the help of optical power meters it is easy to obtain the results for all other combinations of gray codes. SOA based gray to binary code results are shown in Table 1 and SOA-MZI based gray to binary code results are shown in Table 2.

TABLE 1: TRUTH TABLE OF SOA BASED OPTICAL GRAY TO BINARY CODE CONVERTER

Gray code (input)				Output power in dB				Binary code (output)			
G_0	G_1	G_2	G_3	B_0	B_1	B_2	B_3	B_0	B_1	B_2	B_3
0	0	0	0	-100	-77.1	-76.2	-65.4	0	0	0	0
0	0	0	1	-100	-77.1	-76.2	31.40	0	0	0	1
0	0	1	0	-100	-77.1	31.40	25.97	0	0	1	1
0	0	1	1	-100	-77.1	31.40	-65.4	0	0	1	0
0	1`	0	0	-100	31.4	25.97	21.79	0	1	1	1
0	1	0	1	-100	31.4	25.97	-65.4	0	1	1	0
0	1	1	0	-100	31.4	-76.2	-65.4	0	1	0	0

0	1	1	1	-100	31.4	-76.2	21.72	0	1	0	1
1	0	0	0	37.4	31.4	25.97	32.20	1	1	1	1
1	0	0	1	37.4	31.4	25.97	-65.4	1	1	1	0
1	0	1	0	37.4	31.4	-76.2	-65.4	1	1	0	0
1	0	1	1	37.4	31.4	-76.2	29.24	1	1	0	1
1	1	0	0	37.4	-77.1	-76.2	-65.4	1	0	0	0
1	1	0	1	37.4	-77.1	-76.2	21.72	1	0	0	1
1	1	1	0	37.4	-77.1	31.40	25.97	1	0	1	1
1	1	1	1	37.4	-77.1	31.40	-65.4	1	0	1	0

TABLE 2: TRUTH TABLE OF SOA-MZI BASED OPTICAL GRAY TO BINARY CODE CONVERTER

Gray code (input)				Output power in dB				Binary code (output)			
G_0	G_1	G_2	G_3	B_0	B_1	B_2	B_3	B_0	B_1	B_2	B_3
0	0	0	0	-100	-36.7	-22	-6.75	0	0	0	0
0	0	0	1	-100	-36.7	-22	31.52	0	0	0	1
0	0	1	0	-100	-36.7	31.42	15.53	0	0	1	1
0	0	1	1	-100	-36.7	31.42	-6.75	0	0	1	0
0	1`	0	0	-100	31.4	15.53	13.53	0	1	1	1
0	1	0	1	-100	31.4	30.01	15.39	0	1	1	0
0	1	1	0	-100	11.8	-22	-6.75	0	1	0	0
0	1	1	1	-100	31.4	-22	15.39	0	1	0	1
1	0	0	0	37.4	15.9	13.51	13.09	1	1	1	1
1	0	0	1	37.4	15.9	13.51	-6.75	1	1	1	0
1	0	1	0	37.4	15.9	-22	-6.75	1	1	0	0
1	0	1	1	37.4	15.9	-22	-6.75	1	1	0	1
1	1	0	0	37.4	-36.7	-22	-6.75	1	0	0	0
1	1	0	1	37.4	-36.7	-22	15.53	1	0	0	1
1	1	1	0	37.4	-36.7	15.53	13.53	1	0	1	1
1	1	1	1	37.4	-36.7	15.53	-6.75	1	0	1	0

V. CONCLUSION

The results and analysis of this paper are useful for the development of all-optical gray-to-binary code converter by different techniques. Here we have simulated and demonstrated gray-to-binary code converter with the help of SOA and SOA-MZI. Extinction ratio of 131.40 dB is obtained by SOA technique and 131.52 dB by SOA-MZI. All designing was performed at 10 GB/s. So SOA-MZI configuration used in this paper is more desirable than any other designs. Outputs are justified on the basis of 40 dBm power level of gray-to-binary code converter without any additional pump signal. Designs are analyzed in optisystem software in all-optical domain.

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