DESIGN AND SIMULATION OF OPTICAL OR GATE USING SLM AND SAVART PLATE

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Abstract: The demand for faster optical communication networks has been on the rise in the recent years. To accommodate this demand, the new generation of optical communication networks is moving towards terabit per second data rates. Such data rates can be achieved if the data remain in the optical domain eliminating the need to convert the optical signals to electronic signals and back to optical signals. To process such enormous data at a high speed, both ultra-high speed processing systems and novel approaches in processing techniques are required. In this paper, I have designed and implemented an Optical New Quadruple Universal Gate (QUG) using Spatial Light Modulator (SLM) and Savart Plate. The principle of operations of the gates has been explained and a theoretical model is used to fulfill this task, finally confirming through logical simulations.

Index Terms: Multi Valued Logic (MVL), New Quadruple Universal Gate (QUG), Spatial Light Modulator (SLM), Savart Plate.

I. INTRODUCTION

In recent years, the multi-valued logic (MVL) system is becoming highly praised by the scientific community for its inherent property of handling huge volume of data. The main advantages for optical processors lie in the parallel operation but it is also possible to implement MVL in optical system using the polarization states of light along with its presence or absence also[1,2]. The quadruple-valued logic (QVL) system using SLM and Savart Plate is already implemented [3,4,5]. The light incident on Savart Plate is splitted into two orthogonal components and comes out with a spatial shift between them. The electrically addressable negative SLMs are used for the controlling of two components of input light beam. The nature of the negative SLM is such that it is transparent when there is no electric voltage applied on it and it becomes opaque when an electric voltage is applied on it. The property of positive SLM is just reverse. Hence the input may be considered as in the form of di-bit (two bits) representation. In the implementation of QVL system the different states are represented with a di-bit representation using presence and absence of light of two orthogonal polarization states of light beam. The different states are represented with a di-bit representation using presence and absence of light along with the two orthogonal polarization states of light beam [1].

The available universal gates are NAND and NOR Gates. The NAND gate is already implemented by SOA-based Mach–Zehnder interferometer (MZI) [6]. A new universal gate named as NAND has been already designed and implemented [7]. All the above mentioned optical gates provide high speed operation but they can not handle huge volume of data due to representation in binary domain. With this aim, in this paper we have presented Optical New Quadruple universal gate (QUG) using SLM and Savart Plate. In this paper a quadruple OR gate is implemented using this QUG. The superiority of the proposed scheme is verified by simulation results.

II. OPTICAL NEW QUADRUPLE UNIVERSAL GATE (QUG)

The proposed new quadruple universal gate is shown in the Fig 1. Using this gate one can easily implement the operation of all other logic gates like NOT, AND, OR, NAND, NOR, XOR and XNOR.

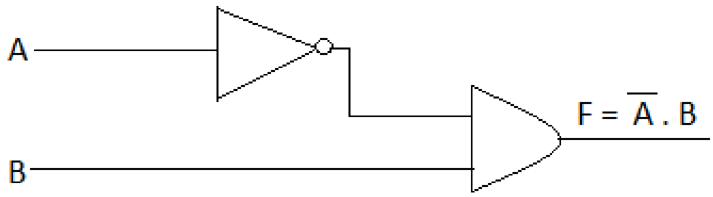

Fig.1: Basic diagram of New Quadruple Universal Gate

In this case A and B are considering as inputs of the proposed new QUG and F= $\bar{A}$.B as the output. The diagrammatic representation of the gate is shown in the Fig 2.

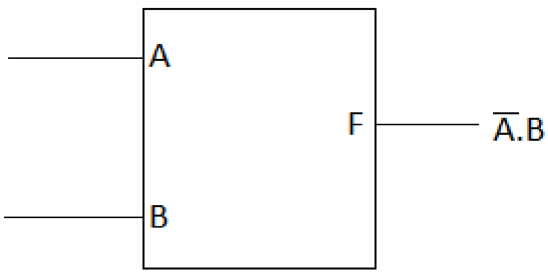

Fig.2: Block diagram of New Quadruple Universal Gate

Now, the new quadruple universal gate implementation is discussed optically using SLM (Spatial Light Modulator) and Savart plate. Here the input A is considered in its di-bit form as A_1 and A_2 and B as B_1 and B_2. The New Quadruple Universal Gate has been optically synthesized in Fig 3. In the circuit the Savart plates S_1,S_2,S_3,S_4 and S_5 form the NOT gate and Savart plates S_7,S_8,S_9 and S_{10} constitute the AND gate.

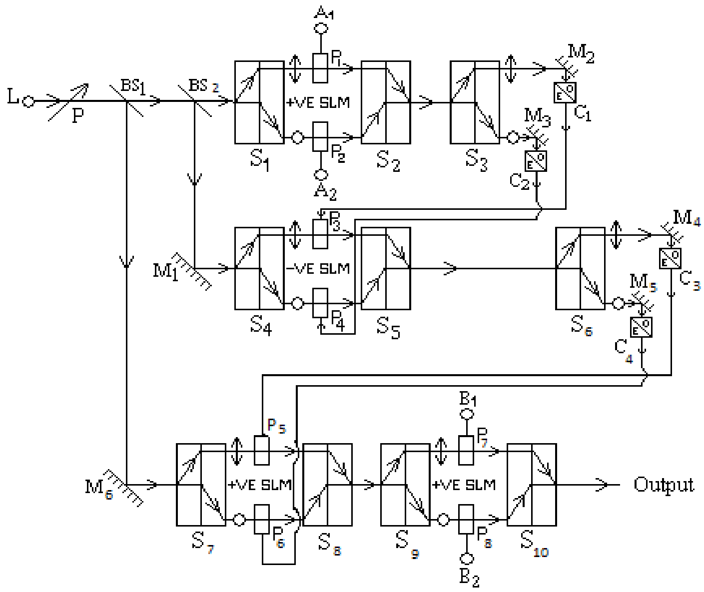

Fig.3: Optical New Quadruple Universal Gate

III. IMPLEMENTATION OF QUADRUPLE OR GATE USING NEW QUG

A gate is said to be universal gate if any basic logic gate can be implemented using this gate. In this section a Quadruple OR gate is implemented using the Optical New Quadruple Universal Gate.

I am considering Y (Y_1, Y_2) as one of the inputs to the first block and the other input is 3 (1, 1). The output (F_1) of this first block is complemented Y that is again fed as the second input to the second block. The first input of this block is X (X_1, X_2). The output of this second block is $F_2=\bar{X}.\bar{Y}$. This output is fed as first input of the third block. The second input of this block is 3 (1, 1). The output of this block gives the final output F_3 = X+Y.

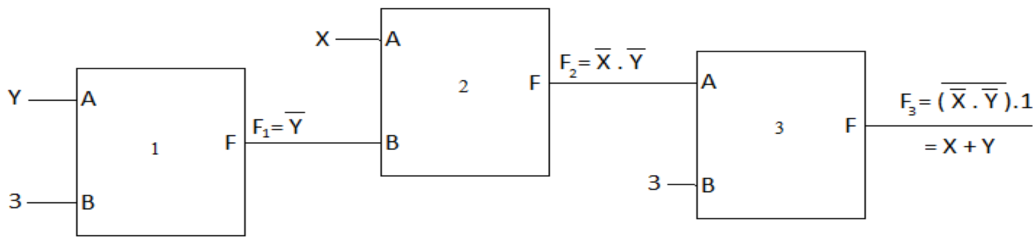

Fig.4: Block diagram of Quadruple OR gate using New Quadruple Universal Gate

The truth table for the Quadruple OR gate for all the possible combinations of the input X and Y is shown in the Table 1.

Table 1: Truth table of Quadruple OR gate using New Quadruple Universal Gate

INPUTS						**OUTPUT**		
X	**X_1**	**X_2**	**Y**	**Y_1**	**Y_2**	**F_{31}**	**F_{32}**	**F_3**
0	0	0	*0*	0	0	0	0	*0*
0	0	0	*1*	0	1	0	1	*1*
0	0	0	*2*	1	0	1	0	*2*
0	0	0	*3*	1	1	1	1	*3*
1	0	1	*0*	0	0	0	1	*1*
1	0	1	*1*	0	1	0	1	*1*
1	0	1	*2*	1	0	1	1	*3*
1	0	1	*3*	1	1	1	1	*3*
2	1	0	*0*	0	0	1	0	*2*
2	1	0	*1*	0	1	1	1	*3*
2	1	0	*2*	1	0	1	0	*2*
2	1	0	*3*	1	1	1	1	*3*
3	1	1	*0*	0	0	1	1	*3*
3	1	1	*1*	0	1	1	1	*3*
3	1	1	*2*	1	0	1	1	*3*
3	1	1	*3*	1	1	1	1	*3*

Now, I am going to represent the quadruple OR gate using the New Quadruple Universal Gate optically by using SLM (Spatial Light Modulator) and Savart plates as shown in Fig. 4.

For the input X=0 (X_1= 0, X_2= 0), and Y=2 (Y_1=1, Y_2=0), the final output consists of only horizontally polarized light i.e. F_2 (F_{31}= 1 and F_{32}= 0).

For the input X=1 (X_1= 0, X_2= 1), and Y=3 (Y_1=1, Y_2=1), the final output consists of both the vertically and horizontally polarized light i.e. F_3= 3 (F_{31}= 1, F_{32}= 1).

For the input X=3 (X_1= 1, X_2= 1), and Y=2 (Y_1=1, Y_2=0), the final output consists of both the vertically and horizontally polarized light i.e. F_3=3 (F_{31}= 1, F_{32}= 1).

In the similar way the other cases can be explained according to Table 1.

IV. SIMULATION (BY MATLAB7.0) RESULT OF THE DESIGNED GATE

The vertical axis in Fig. 6 shows power in dB, while horizontal axis represents time scale in ps. The timing instant for the occurrence of bit pattern is at 1,3,5,7 ps. Upper first two (Fig. 6(a) and Fig. 6(b)) set waveforms indicate the input bit sequences **0011** and **0101** for the input variables A and B respectively. Similarly, from different output bit patterns gives the different input bit combinations which satisfy the truth tables of OR gate.

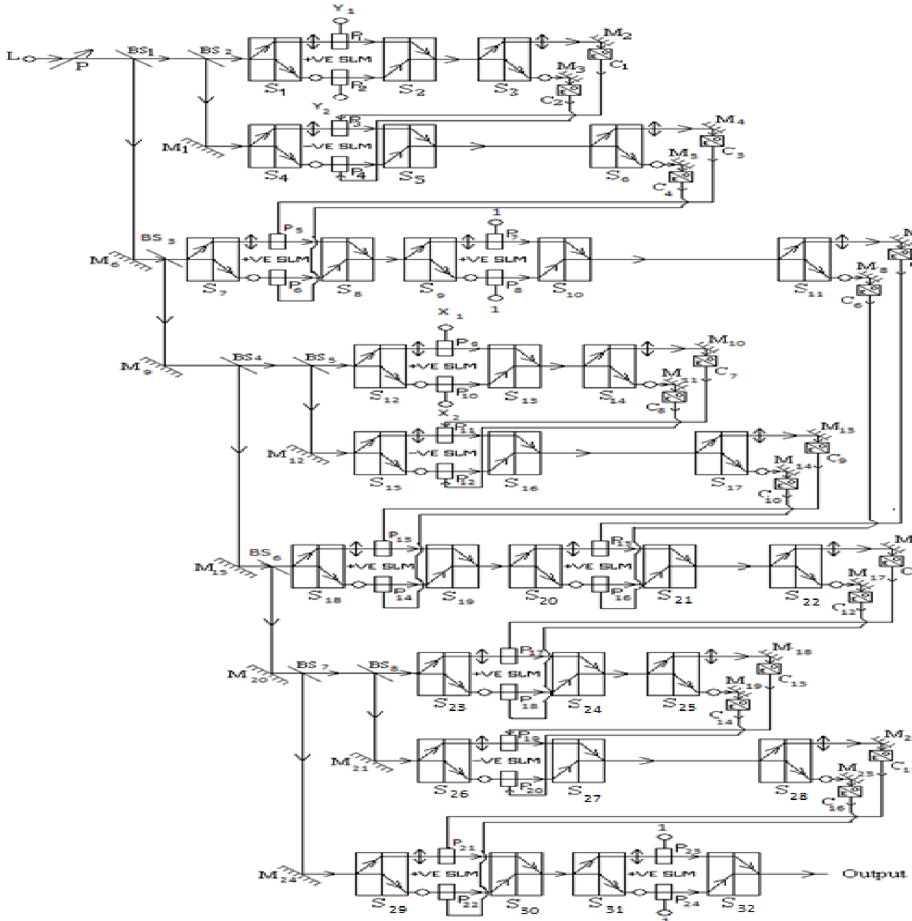

Fig.5: Optical Quadruple OR gate using New Quadruple Universal Gate

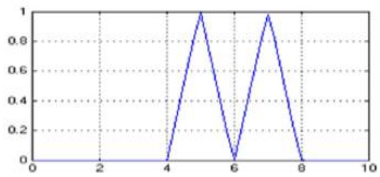

Fig. 6(a): Input X

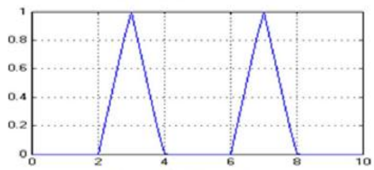

Fig. 6(b): Input Y

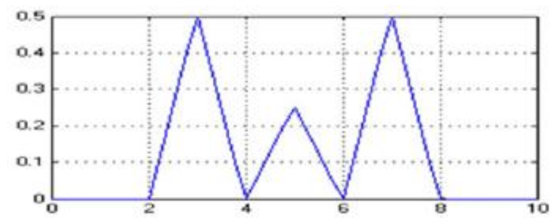

Fig. 6(c): Output of OR gate

V. CONCLUSIONS

In this paper, Optical New Quadruple Universal gate (QUG) has been implemented along with the realization of optical OR gate using this QUG. Simulation result verifies the functionality of the designed OR gate. The theoretical models developed and the results obtained numerically are useful to future all-optical logic computing system. It has some limitations regarding optoelectronic conversion delays and dense organization of optical processing units, but it also has wide range of applications in complex combinational, sequential circuits as well as in communication fields and optical computational circuitry.

VI. REFERENCES

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