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A New Logic Gate for High Speed Optical Signal Processing Using Mach- Zehnder Interferometer (MZI)

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***Abstract*— with the increasing demand of high speed optical communication, Reversible Logic (RL) gate has an optimal solution. This logic gate overcomes the shortcomings of classical logic gates in field of power dissipation for every bit of signal to be processed and also high data transfer rate without any signal distortion. This paper presents the design and simulation of 3x3 Reversible Logic (RL) gate using Mach- Zehnder Interferometer at 40 Gb/s data rate in OptiSystem software. The simulation of Reversible Logic Gate will be used for ultra high speed communication applications in future.**

***Keywords*:** Reversible Logic (RL), Mach-Zehnder Modulator (MZI).

I INTRODUCTION

The primary goal of RL gate is to reduce the power dissipation and high bit rate in comparison to classical logic gate. There are lots of other techniques through which RL gate can also be implemented such as Ultra-fast Non linear Interferometer (UNI), Tetrahertz Optical Asymmetric Demultiplexer (TOAD) and Mach- Zehnder Interferometer (MZI). Among the different configurations, MZI represent the better solution because of its compact size, less power dissipation, less switching energy, high relative stability, and greater thermal stability. Basically MZI comprises two 3 dB coupler. The one at the input side works as splitter while the one at the output side works as phase changer. Both arms of MZI have different length so to achieve the desired phase change (Δø) (5) which is given by

$$\Delta\phi = M\Delta X$$

Where, $M = 2\pi z/\lambda$

λ =wavelength

z = any integer

This phase change results to constructive or destructive interference of optical signal after combining. If the phase change is odd integer multiple of π, then the signal, then the signal comes out through the upper arm of MZI which is also known as bar port. If the phase change is even integer multiple of π, then the signal comes out through the lower arm of MZI which is also known as cross port.

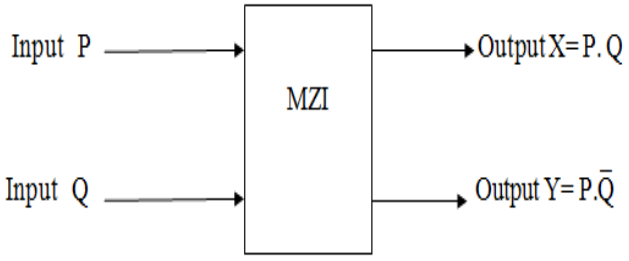


Figure 1 Representation of MZI switch

Input P	Input Q	Output X	Output Y
0	0	0	0
0	1	0	0
1	0	0	1
1	1	1	0

Table 1 MZI Switch Truth Table

The phase changing property or switching property of MZI switch is used widely. This property can be used in implementing the digital logic gates such as AND Gate, OR Gate, NAND Gate and other logical gates as well. This property is also used in implementing flip flops, Multiplexers, De-multiplexers and Bit shifters. The RL gate having three different inputs is designed using this property.

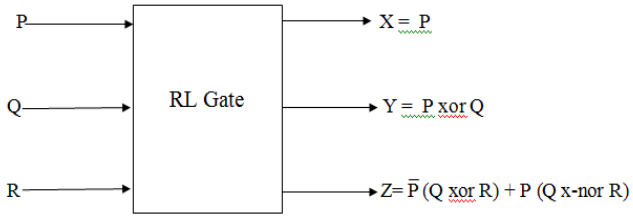


Figure 2 Representation of RL Gate

II IMPLEMENTATION OF RL GATE USING Mach-Zehnder Interferometer

The new RL Gate is implemented in optical domain using Mach-Zehnder Interferometer, Beam coupler, Splitter and NOT Gates and AND Gates. The implementation of RL Gate is shown in Figure2.

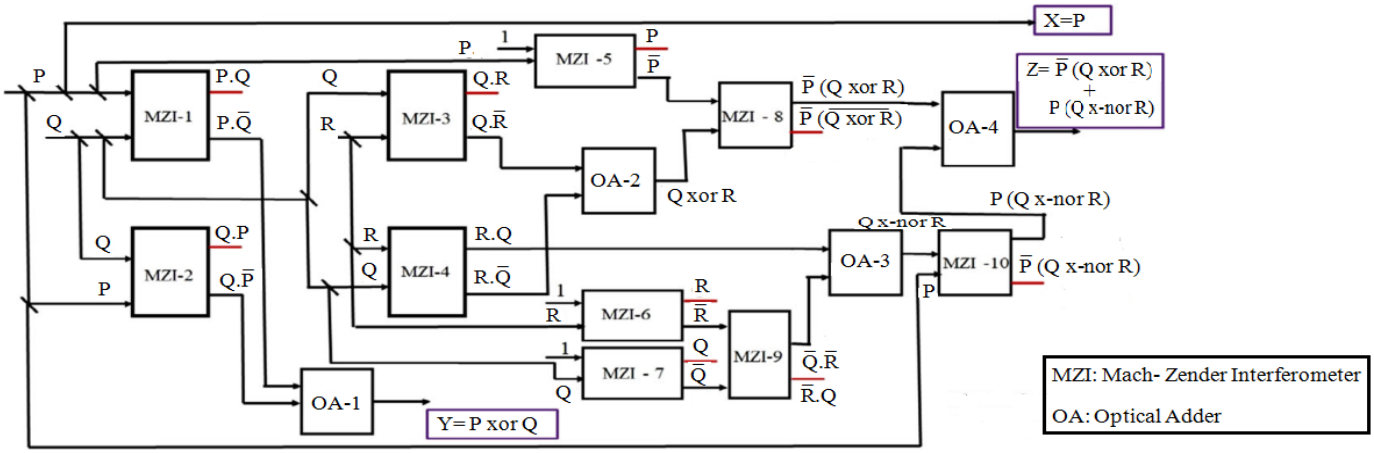


Figure 3 Implementation of RL Gate

The inputs P, Q and R at 10 Gb/s are generated using Pseudo Random sequence generator and pass it to the Optical Gaussian Pulse generator to generate the optical pulse and then fed to MZI switch according to the figure 3. The outputs are visualized using optical time domain visualiser. To visualize the eye diagram and Q factor, the output optical signal is then passed to optical receiver or photodiode and followed by a BER analyzer to get values of Q factor, eye diagram and minimum BER of corresponding bit.

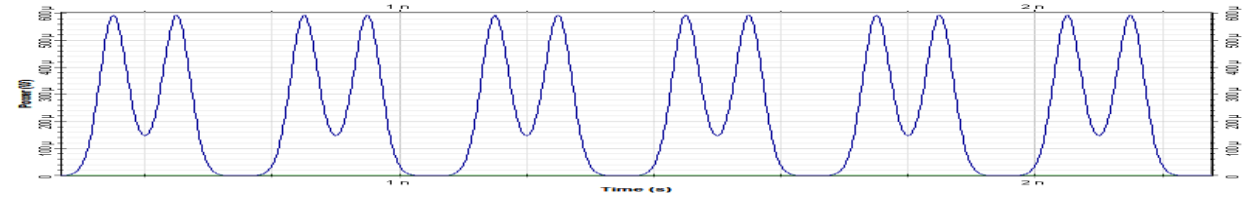
III SIMULATION RESULT

The proposed RL Gate is designed using Optisystem software. The input data sequence and output sequence which are used during simulation are represented in table as follows:

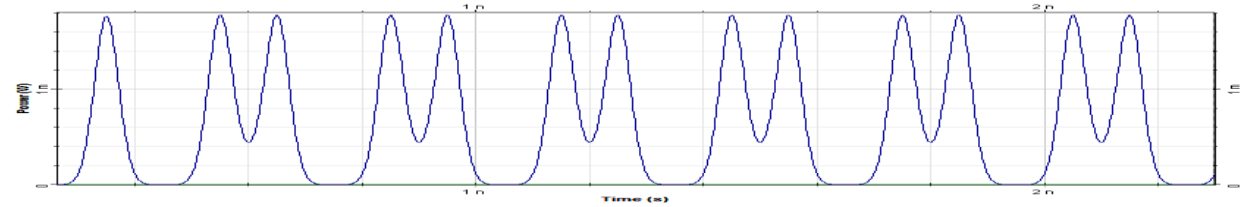
Table 2 Input and output sequence during Simulation

Input			Output		
P	Q	R	X	Y	Z
1	1	0	1	0	0
1	0	1	1	1	0
0	1	0	0	1	1

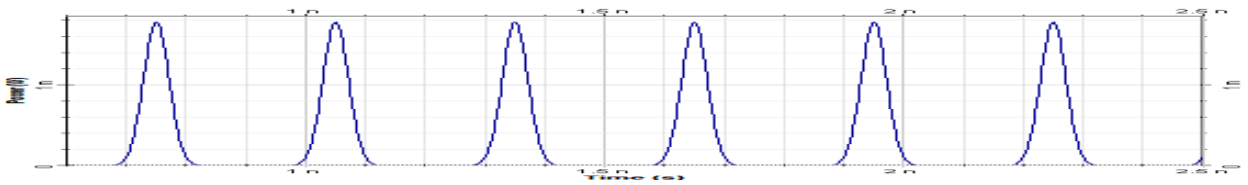
The representation of input sequence in optical domain is shown in Figure 4 and the optical signal obtained at different stages of proposed design is shown in Figure 5. The presence of pulse represents logic 1 while its absence represents logic 0.



P = 110



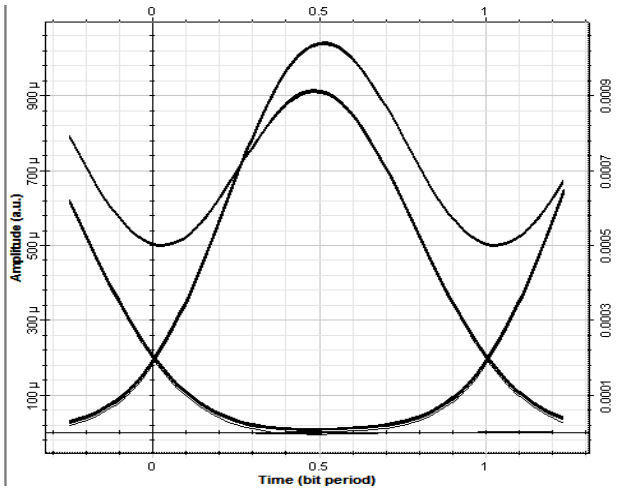
Q = 101



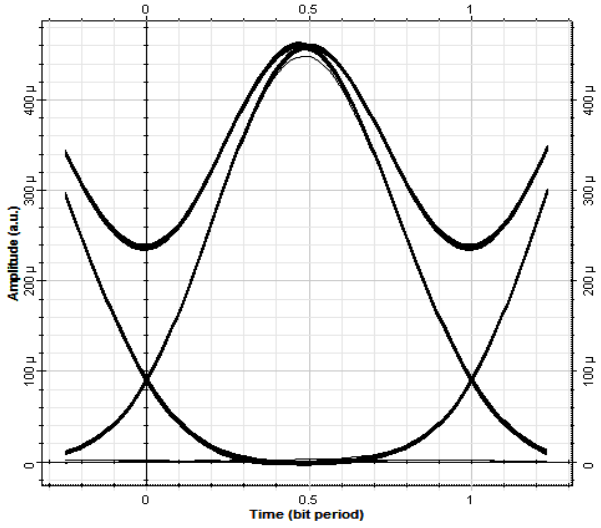
R = 010

Figure 4 Representation of Input Sequence in Optical Domain

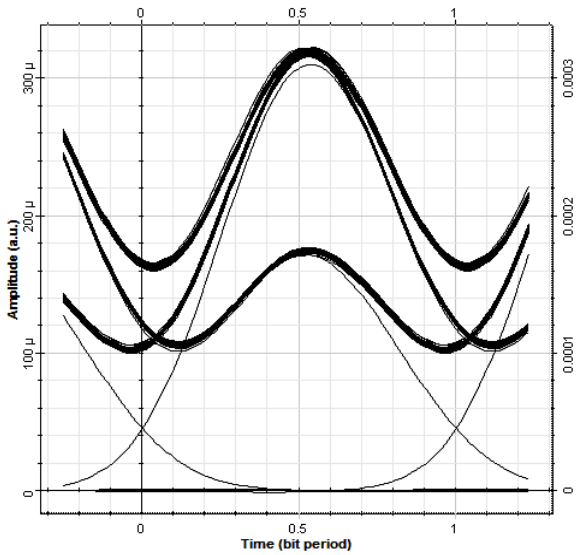
The eye diagram for output data sequence of RL Gate is shown in Fig 5. With the help of eye diagram, the Q factor and Min BER is also analyzed and listed in table3.



X(MSB)



Y



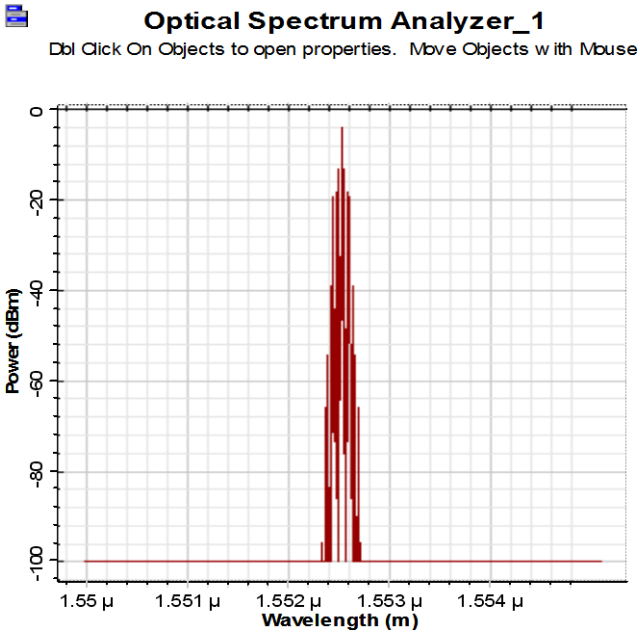
Z(LSB)

Figure 5 Eye Diagram of output Sequences

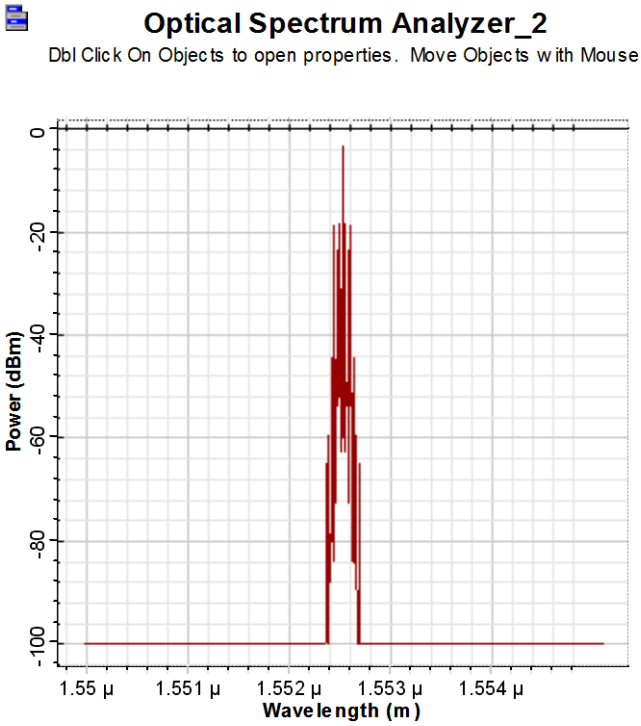
Table 3 Performance parameters of RL Logic Gate

Output Bit	Min BER	Max Q-factor
X (MSB)	0	317.166
Y	0	74.939
Z (LSB)	1.071e−051	15.064

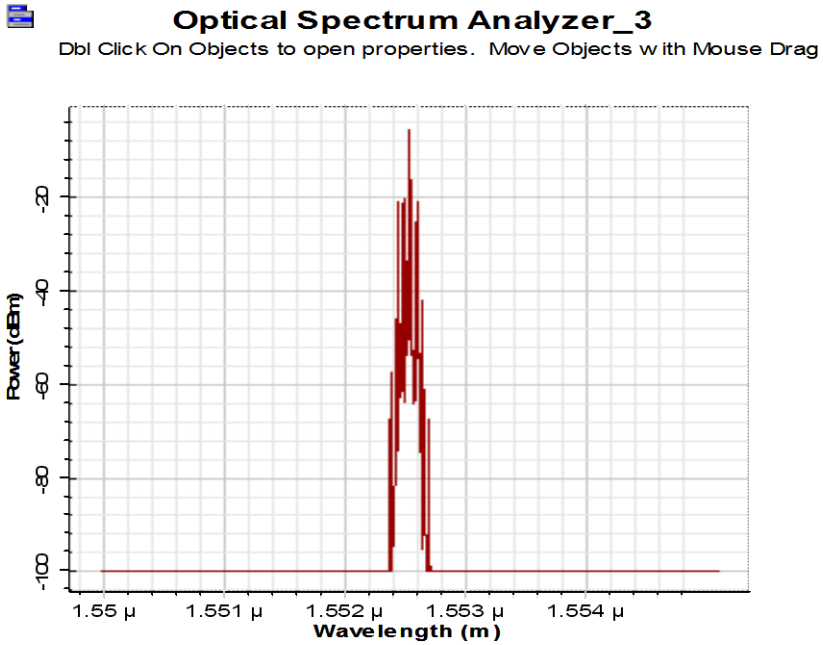
The values of BER indicate the error free transmission of signal from input to output stage. The Optical Spectrum of output bits of RL Logic Gate is shown in Figure 6. The simulation set up in Optisystem Software is shown in Figure 7.



X(MSB)



Y



Z(LSB)

Figure 6 Optical Spectrum of Output bits of RL Logic Gate

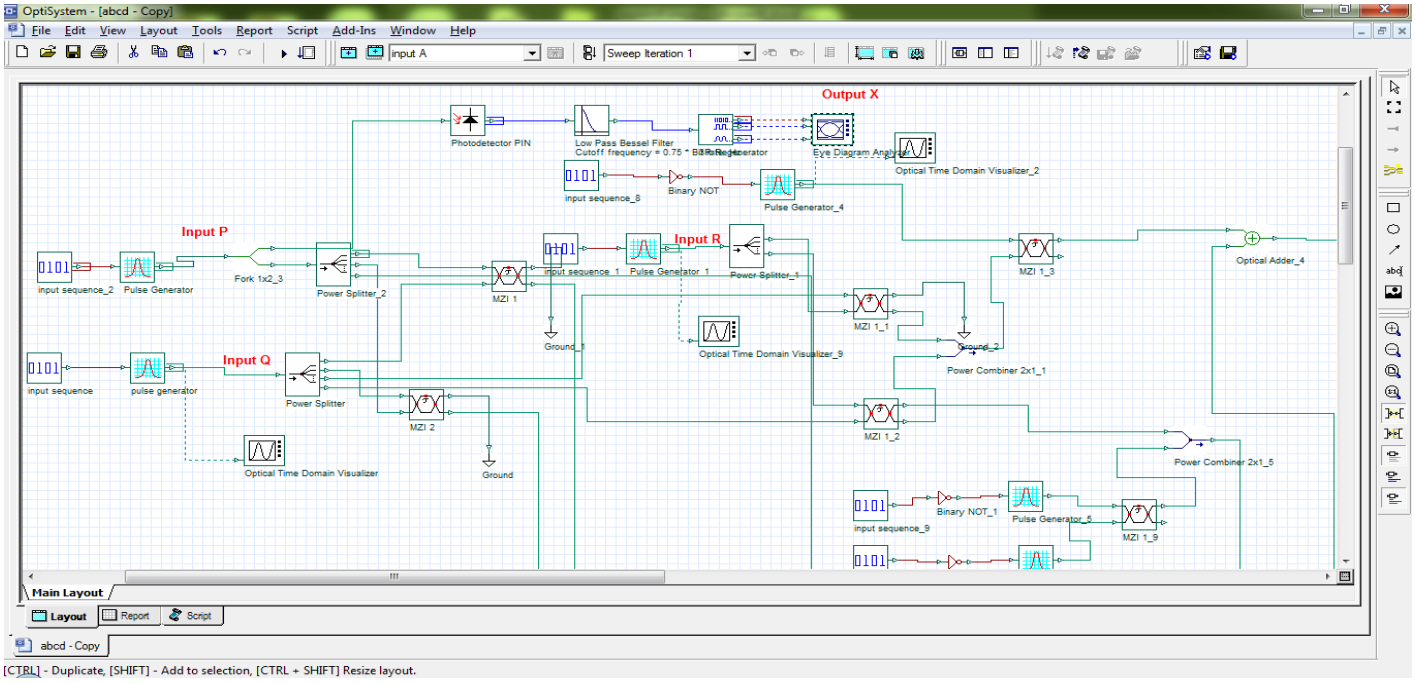


Figure 7 Simulation set up in Optisystem Software

IV CONCLUSION

The RL Logic Gate is presented in this paper. The RL Gate is implemented using MZI in optical domain. The BER and Q factor of the output bits are analyzed and results are obtained. The RL Logic Gate can be used in designing Full Adder, Full Subtractor, Optical ALU, Optical RAM etc and also for high speed communication system.

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