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A Novel Design "Binary to Gray Converter" with QCA Nanotechnology

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Abstract:- *Quantum dot Cellular Automata (QCA) is a new direction in creating logic circuits based on nanotechnology.It is a promising alternative to CMOS technology with many appealing features such as high speed, lowpower consumption and higher switching frequency than transistor basedtechnology.The code converters are the basic unit for alteringof datato perform arithmetic processes. In this paper, QCA based3-bit binary to gray and 4-bit binary to gray code converter, with a minimum number of cells, has beenproposed.The simulations are completed using QCA Designer.*

Keywords: *Binary to Gray Converter; Quantum Dot Cellular Automata; QCA cell;Gray code.*

1- INTRODUCTION

Digital industry properties have been changed in the few past years by virtue of technology improvement.Physical limits of CMOS such as the effects of quantum andthe limits of technologies like power dissipation,obstruct the momentumof microelectronics using regular circuit scaling. QCA is an emergingtechnology which allows operating frequencies in the range of THz that is notattainablein CMOS technologies. The key unitof QCA compositionis QCA cell that involves four electrons. The position of electrons signifiesthe bit either binary 0 or 1. The keyprocess is the interaction between the cells by means columbic force.This paper concentrateson the design a novel structure of binary to gray converter based on a new of XOR gate which proposed by [1]. QCA designer is the simulator which can be used to design any combinational and sequential circuit and then simulate the designed circuit. In QCA Designer we can design the required circuit using cells or arrays, rotate them, copy the structure for multiple uses and provide clocks tom it to make it work at different time interval. Hence QCA designer is an effective tool to design any combinational and sequential circuit [2].

2- FUNDAMENTAL OF QCA

The QCA cell represents the key unit of QCA structure and it contains two electronswith four quantum dots positioned at the vertices of a square cell. Electrons can move to different quantum dots by means of electron tunneling.The electrons are forced to the corner area to expand their separation due toCoulomb repulsion. The state of a cell is called its polarization. The two electrons of the QCA cell are arranged to be identical energetically nominal. The two electrons in this arrangement, shown in Figure 1, exhibit high stability. These are denoted as cell polarization P=+1.00 and P= -1.00. These cell polarization can represent logic "1" and logic "0", respectively, in the QCA cell composition..

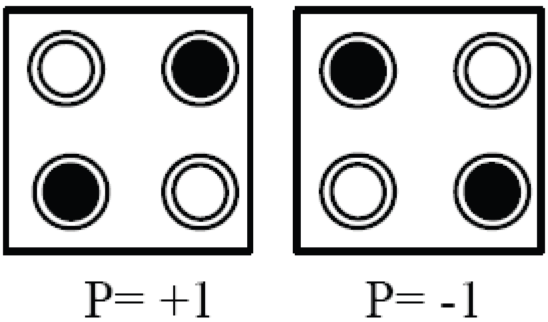


Figure 1: Structure of a basic QCA cell.

Several QCA combinational, sequential and reversiblelogic circuits have been proposed in recent years depending on inverters with two cells arrangement and a three input majority voting elements. The inverter and the majority gate are the essential elements constituting the QCA structure. [3].

2.1 QCA Wire

In a QCA wire shown in Figure 2, a propagation of the input to output binary signal occurs due to electrostatic interaction among cells. Only half of the wire would be actively propagating the signal in a clock cycle, the other half would be in a state of depolarization. During the following clock cycle, deactivation to half of the previously active clock zone happens, while the new active cells are triggered to be polarized by the remaining active zone cells. Consequently, signals are propagated between each two consecutive clock zones [4].

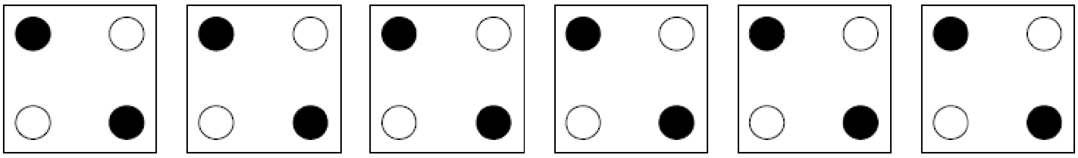


Figure 2: QCA wire

2.2 QCA inverter

QCA inverter is generally constructed by positioning the cells with only their corners contacts. This aspect is employed to shape an inverter as shown in Figure 3.QCA inverter returns the reversed value of the input value [3].

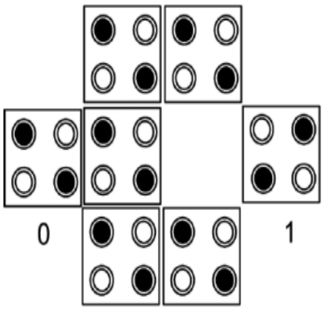


Figure 3: QCA inverter

2.3 Majority voter (MV)

The MV has incorporate four terminal cells. Among these terminals three are determining asinput terminal cells and resting one determining as output cell. Majority Gateis expressed as logic function MV (A,B, C) = AB + BC + AC.producing QCA design that is organized well, requires implementing the digital circuit with the assistance of majority gate based design techniques.Logical AND gate and OR gate can be realized from the majority gate asshown in Figure 4 [3].

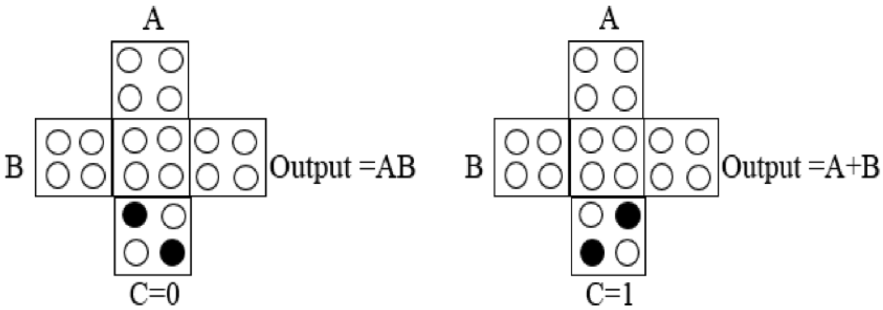


Figure 4: 2-input AND gate and 2-input OR gate using Majority voter.

3- CODE CONVERTERS

The wide variety of codes to represent discrete elements of information, lead them, being used by different digital systems. However, in some cases, the need to connect the output of one digital system to the input of another digital system arises..Betweenthese two systems, the conversion circuit must be inserted if each uses different codes for the same information. Therefore a code converter is a circuit that makes both systems compatible even though each uses different codes. Without a doubt, the effectiveness of code converters was proven by the National Security Agency (NSA), since they utilized them while creating and breaking codes. Code converters can be very helpful for protecting sensitive data from spies. Code converters are also useful for enhancing tractability and portability of the data. Code converters have also found applications in communication and algorithm generation. Binary to gray code converter shown in Table 1 is one of the most important converters used in digital systems [5].

Table 1:[(a)3bit(b)4bit]Binary to Gray code converter

Binary Inputs			Gray Outputs		
B0	B1	B2	G0	G1	G2
0	0	0	0	0	0
0	0	1	0	0	1
0	1	0	0	1	1
0	1	1	0	1	0
1	0	0	1	1	0
1	0	1	1	1	1
1	1	0	1	0	1
1	1	1	1	0	0

(a)

Binary Inputs				Gray Outputs			
B3	B2	B1	B0	G3	G2	G1	G0
0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	1
0	0	1	0	0	0	1	1
0	0	1	1	0	0	1	0
0	1	0	0	0	1	1	0
0	1	0	1	0	1	1	1
0	1	1	0	0	1	0	1
0	1	1	1	0	1	0	0
1	0	0	0	1	1	0	0
1	0	0	1	1	1	0	1
1	0	1	0	1	1	1	1
1	0	1	1	1	1	1	0
1	1	0	0	1	0	1	0
1	1	0	1	1	0	1	1
1	1	1	0	1	0	0	1
1	1	1	1	1	0	0	0

(b)

4- SIMULATION AND RESULT

Based on XOR gate which proposed by [1] shown in Figure 5, the code converter circuits have been designed using QCA Designer 2.0.3.

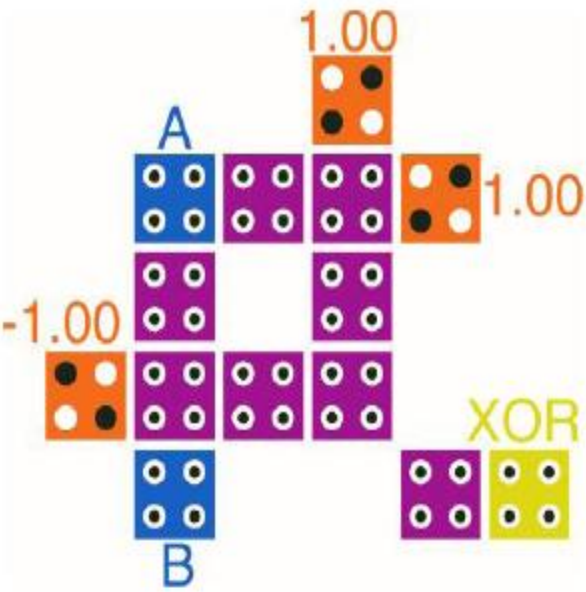


Figure 5: layout of XOR gate proposed by [1]

The circuit layouts and simulation result of 3-bit binary to gray and 4-bit binary to gray code converter are shown in Figure 6 and Figure 7 respectively.

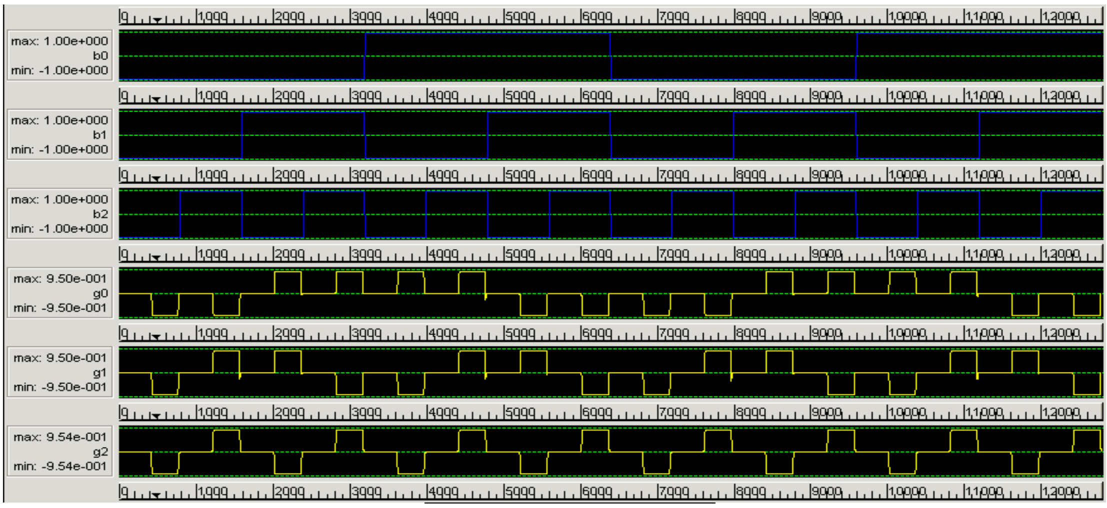
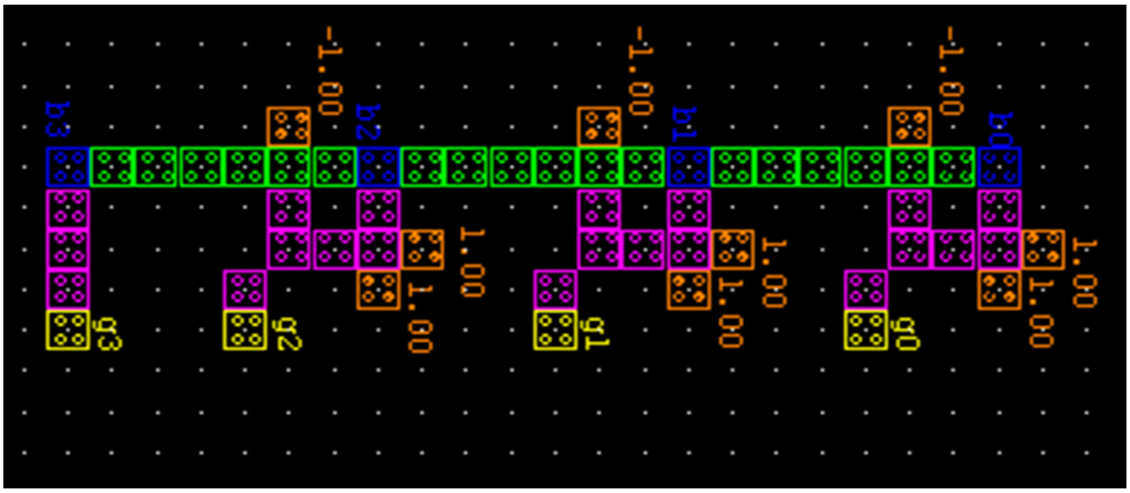


Figure 6:circuit layout and simulation result for 3-bit binary to gray converter



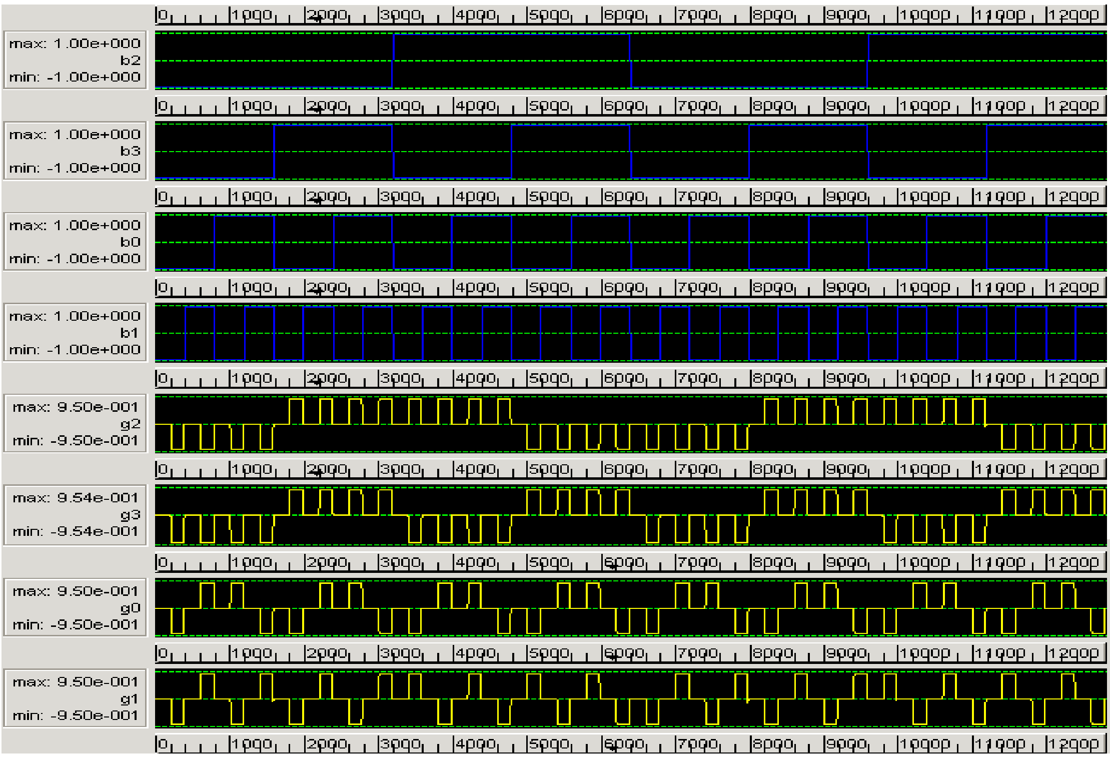


Figure 6:circuit layout and simulation result for 4-bit binary to gray converter

Figure 7 represent the complexity of proposed circuit compared with the circuit which introduced by [6]

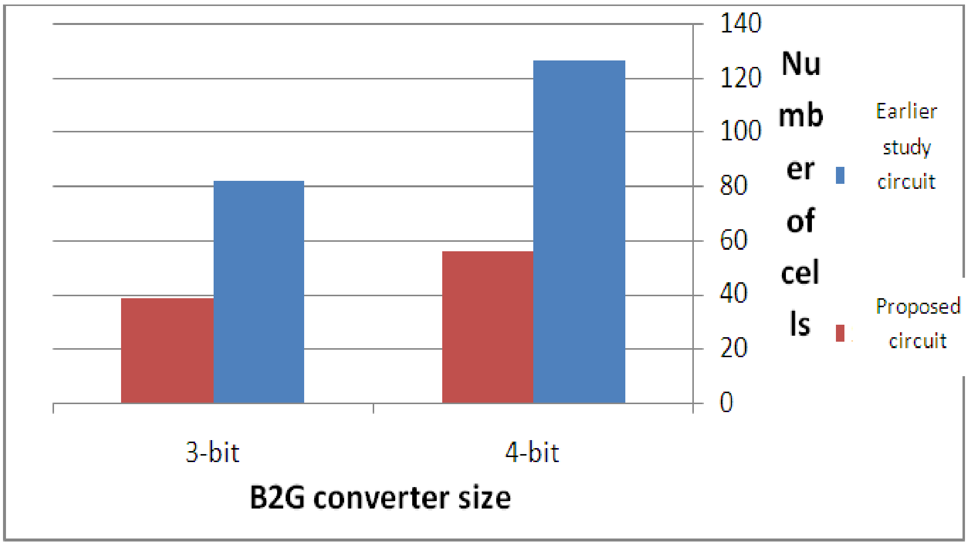


Figure 7:circuit complexity compared with an earlier study

5- CONCLUSION

In this paper, the design and simulation of a QCA binary to gray code converter circuits has been presented. The operation of these converters has been analyzed using QCA designer bi-stable vector simulation. The designs are efficient where it contains less number of cells, useminimum clock phases and have significantly minimum wire length which causes to trouble-free operation at higher temperature. The proposed converter has an advantage in terms of number of cells (65% for 3-bit and 56% for 4-bit) from an earlier circuit proposed by [6].

6- References

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