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Implementation of One Bit Adder using Quantum Dot Cellular Automata

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***Abstract*: Quantum dot cellular automation (QCA) is witnessing advancements in nanotechnology in 21st century. Over last 10 years QCA has got tremendous importance as it operate in a very low power, it can attain a very high frequency (usually in Tera-Hertz) and we can make dense circuit for implementing any digital circuit. This work presents a compressed QCA full adder which has an extended ability to form multiple adder circuit.**

***Keywords*: Automation, Nanotechnology**

1. Introduction

Quantum Dot Cellular Automata (QCA) is a new technology in the nanometer scale and have been considered as one of the alternative to CMOS technology. QCA has large potential in the development of circuits with high space density and low heat dissipation and allow the development of faster computers with lower power consumption. Quantum dots are nanostructures created from standard semi conductive materials having two electrons and two holes. A single dot in the cell can be visualized as a well higher energy is required for electron to escape from the dot. Quantum dot cellular automata is new technology that helps us to creates general functionality at the nanoscale by specifying the position of single electron.

2. QCA Computation

- Complete logic set is required to perform logic computing. A set of Boolean logic gates are constructed that can perform AND, OR, NOT and FAN IN and FAN OUT operations. The combination of these is considered as universal because any Boolean function can be implemented with the combination of these logic primitives. The fundamental method for computing is majority gate or majority voter method. Suppose three inputs are given to QCA circuit, then the output of the QCA structure is tabulated in table.
- Majority of the inputs are reflected by the majority gates. Threshold functions are the larger functions which are the part of majority functions. Threshold functions works according to inputs. The most fundamental logic gate in QCA circuits are majority functions. In order to create an AND gate we simply fix one of the majority gate input to 0 (P = -1). To create OR gate we fix one of inputs to 1 P = +1. The inverter or NOT gate is simple to implement with the help of QCA.

Table 1
Majority voting scheme

Input	Output Majority Voting Scheme
000	0
001	0
010	0
011	1
100	0
101	1
110	1
111	1

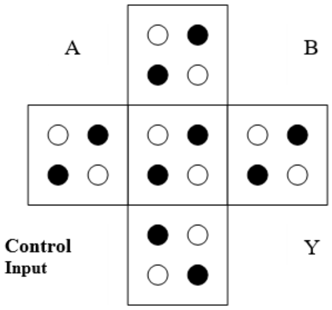

Fig. 1. QCA Majority AND gate. Control input is -1

- The output of majority AND gate reflects the majority of the inputs. Suppose input A =1, B = 1, Control input 0(-1), the output is equal to 1.

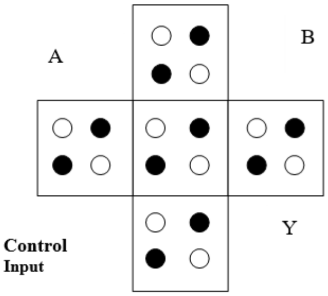

Fig. 2. QCA Majority OR gate. Control input +1

- The majority AND, OR gate are shown in Figure 1 and 2. Control input to AND gate is -1 and for OR gate is +1.

3. Design of QCA circuits

The design of nano electronic circuits and systems requires different approach as like CMOS based VLSI technology. The large density of cells in QCA technology has significant features in the manufacturing of QCA systems and still QCA circuits require versatile building blocks for deposition and circuit assembly. QCA design mostly uses gate based methodology, in gate based design majority function and inverter gates are connected to form the desired circuit. But majority function is not universal, since it requires inversion function for its logical operation to form a complete QCA circuits. Tile based design for QCA gives flexibility in the generations of logic function at higher polarization levels. Routing of signal between the tiles should be made ease so that output cell can be brought to fully polarized state. The nanolithography drawbacks in manufacturing QCA circuit can be rectified using tile based modular QCA design. Each cell in QCA circuit has size of 20nm, and the area is in nanometer square, whereas in tile based design the QCA cells are bunched in to blocks and selected cells are populated and signals can be routed to the target cell and easier achieving the desired logic function. Tile based QCA circuit design requires stable signals, so that no undermined value due to leak of polarization be present at the output.

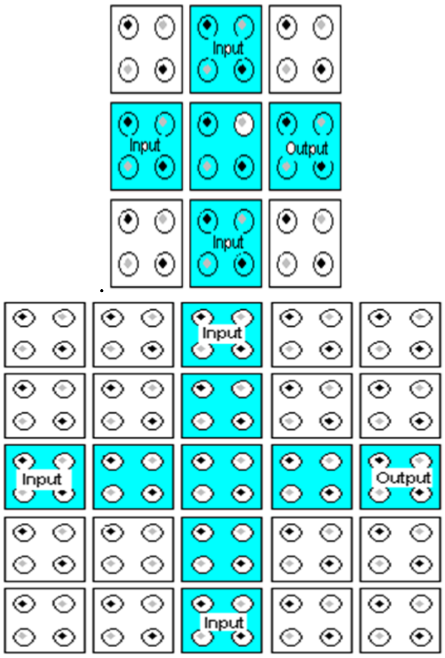

Fig. 3. 3X3, 4X4 QCA tile based block for a majority logic

4. QCA Full adder circuit

QCA addition algorithm is proposed here to simplify majority expressions for design of QCA adder circuits. QCA Full adder is a basic building blocks of QCA systems. QCA full adder consists of three majority gates and one inverter. The full adder circuit has 156 cells with 0.2 micro m^2 in area and time for simulation is 6ns.

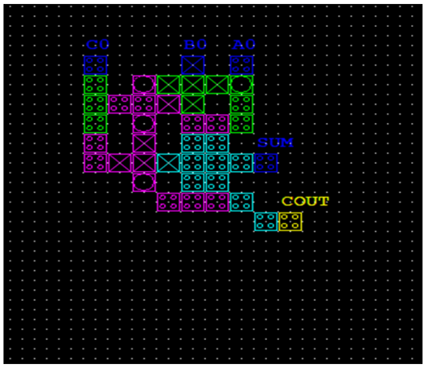

Fig. 4. QCA full adder

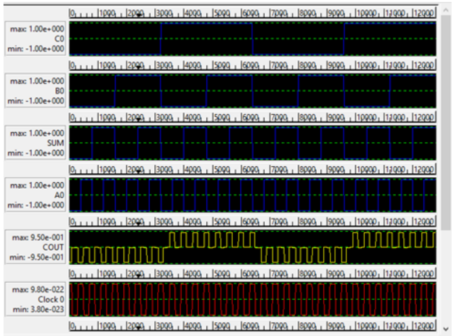

Fig. 5. Simulated waveform of QCA Full adder

5. Conclusion

A novel and efficient single-layer 1-bit QCA full adder architecture was presented. The proposed 1-bit QCA full adder architecture was suitable for designing larger QCA adder units such as the RCA. We have implemented a 4-bit QCA RCA architecture using 1-bit QCA full adder module as its structural unit. The proposed QCA full adder architectures have been simulated using the QCA Designer version 2.0.1.

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