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Energy efficient neoteric design of a 3-input Majority Gate with its implementation and physical proof in Quantum dot Cellular Automata

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Abstract
Quantum dot Cellular Automata (QCA) is one of the most commendable approach besides the other alternative approaches, which has the proficiency to replace a well-known CMOS approach in near future. QCA technology possess small size, high speed of operation, high integration density capacity and ultra-low power consumption at nano-scale level. Various design paradigms of logic circuits related with QCA have been extensively studied in the recent past. A basic design of an Inverter and 3-input majority gate serves the purpose of the fundamental logic gates to design most of the QCA circuits with accuracy. In this presentation, a new design prototype of 3-input majority gate has been proposed, which is best suited to design QCA based circuits in variety of ways according to one’s own need. The proposed 3-input majority gate has the flexibility to change the position of its input as well as output QCA cells location from one place to another according to the need of a particular design. Physical proof and power dissipation analysis is derived for the proposed 3-input majority gate. Simulation results have been obtained by implementing various circuits based on the proposed 3-input majority gate and their output is verified using QCADesigner 2.0.3 tool.

Keyword Majority gate, Ex-OR Gate, Parity Generator and Parity Checker, Full Adder, QCADesigner, QCAPro

Introduction
Quantum dot Cellular Automata (QCA) is one of the state-of-the-art approaches to be implemented for circuit designing at nano scale regime [1-4]. Fig. 1 shows the basic QCA cell. There are four places where electrons can conform inside the cell but electrons will reside at that place which requires minimum energy. Further, both the electrons will get adjust at the uttermost distance possible between them. Coulombic interaction between the electrons is used to gain the necessary computing logic states like logic ‘0’ and logic ‘1’ by utilizing the positions of electrons.

![Fig. 1 QCA Cell (a) empty (b) logic ‘1’ (c) logic ‘0’](image)

Logic from one QCA cell to another QCA cell is passed utilizing cell polarization effect and it continues in all over the circuit till the end, which indicates that there is not any kind of current is flowing in between the QCA cells. Therefore, very less power is consumed by QCA circuits when transition of the state takes place from one logic to another. Fig. 2 shows the QCA wire structure, used to pass information. Fig. 3 shows QCA Inverter structure: one is simple and another is robust, considering the chances for each QCA cell to get fail, so robust structure is used whenever it is essential in the design.

![Fig. 2 QCA Wire](image)

The most important structure in QCA is 3-input majority gate as shown in fig. 4. This gate is important and works as a fundamental gate because any other logic structures like AND gate, OR gate or others can be formed utilizing the 3-input majority gate. By converting one of its three inputs from +1 to -1 logic, we can get AND gate and OR gate consequently. Both the 3-input majority gate
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