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A New Clocking Scheme for Quantum-dot Cellular Automata Based Designs with Single or Regular Cells

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Abstract

Quantum-Dot Cellular Automata (QCA) is one of the newest technologies that play very important role to design Nano scale electronic devices that are likely to meet the requirements of the modern digital systems, as compared to micro fabricated devices in *CMOS technology*. In this paper, we proposed a new clocking scheme for QCA circuits, in which single phase cells (90^0) or regular cells are used. We design combinational circuits with single phase cells. According to the previous clocking schemes there are no such schemes exist where only single phase cells are used for crossing as well as data propagation. In previous coplanar crossover schemes both cells (90^0 and 45^0) are used for circuit design. The main limitation of these schemes is that there is a possibility of cross coupling between the two wires (one of 90^0 and another is 45^0) during fabrication, when placement of any cells are misaligned. In the new scheme only single phase cells are used, so there is no misalignment of cells. Simulation results indicate that our designs with new clocking scheme achieve same results in comparison to the best previous relevant works. Simulation and verification are carried out by QCADesigner.

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Keywords: Quantum-dot cellular automata(QCA); Emerging technology; Multiplexers; Clocking

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1. Introduction

As the *CMOS technology* is going to reach its fundamental physical limits, there has been wide research at nano-scale for the future generation ICs. *Quantum-Dot Cellular Automata (QCA)* is one of the suitable new technologies that not only gives a solution at Nano-scale, but also offers a new method of "*Computation and Information*

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transformation”[1]-[3]. It can also provide the advantage of low-power consumption, high speed computation, and high density. QCA is an important technology for the development of digital systems such as combinational and sequential circuits that can be designed by QCADesigner.

The “*Physical design*” and “*Placement of QCA cells*” present new difficulties. For example, over the conventional *CMOS technology* an additional advantage is the ability of crossing QCA wires on a plane. Like *CMOS technology*, QCA does not propagate signals using voltage level and current level, but rather through “*Columbic interaction”* of electrons, then there is no interference between the cells when they cross each other. Because there is no interference when a line of rotated cells will crossing to a line of regular cells [1]-[3]. However delay will be increased for switching and data propagation when long lines of QCA cells are used. Due to which circuits operating speed reduces using this technology. As QCA operate at room temperature, it requires small lines of cells. Currently, in QCA systems signal propagation is essentially achieved along with serial timing zones as a “*1D technique*” [5]. The 1D technology used for timing the QCA cells [5] and trapezoid technique proposed in [6] attain a higher cell density through feedback paths.

In this paper, we acknowledge the issues related to timing and clocking of QCA systems for high performance computing. Firstly, as we studied various clocking schemes (1D, 2D and 2D-wave clocking schemes) which are used to solve these issues. These schemes are uses both rotated cells and regular cells for data transformation and crossing but to solve these issues we can also use only regular cells. The new clocking scheme proposed, using only regular cells for signal propagation as well as crossing, is based on 1D characterization of data propagation and crossing also. Simulation results using QCADesigner are provided for combinational QCA circuits.

Remainder of this paper is organized as follows. Section 2 represents the background of QCA in which we discuss about QCA cell, its operation, QCA logic and QCA clocking scheme. Section 3 presents the related works (different clocking schemes). Section 4 discuss about proposed clocking scheme (based on 1D scheme with only regular cells). Section 5 presents detailed simulation results using QCADesigner [7]. Section 6 addresses the conclusion and future directions.

2. QCA Background

2.1. QCA Cell

QCA cell is the primary unit of QCA circuit. Each cell is square nanostructure consists four quantum dots (arranged one in each corner). QCA cell consists two extra mobile electrons into it, which are placed diagonally due to columbic repulsion. In each cell these two extra electrons can quantum mechanically tunnel between neighboring sites, but they can’t tunnel outside the cells. The polarization states of these two electrons can be used for binary data representation in cells. Fig. 1 shows two binary states “*0*” and “*1*” with two polarization states *-1* and *+1*, respectively in [3] and [5].

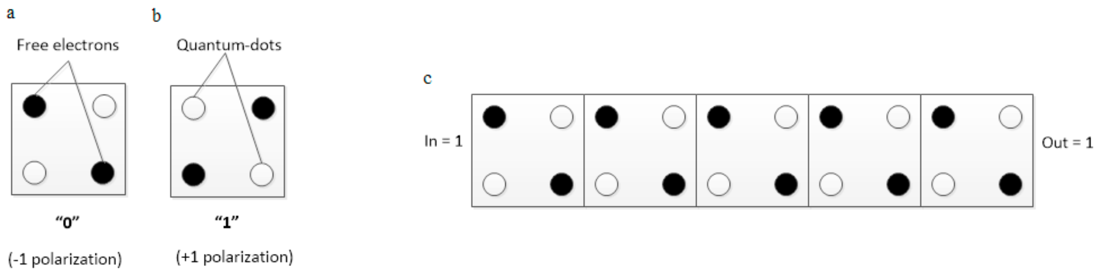

Fig. 1. Representations of Quantum-dot cells (a) Regular cell; (b) Rotated cell; (c) QCA wire.

QCA cells are of two types such as regular cell and rotated cell as shown in Fig. 1(a) and 1(b). The rotated cell (also called 45 degree cell) is used for coplanar crossings. A QCA wire shown in Fig. 1(c) consists a set of cells where the cells are placed adjacent to each other.