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A NOVEL QUANTUM DOT CELLULAR AUTOMATA BASED DESIGN FOR MULTIPLEXERS

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Abstract: ***Quantum-dot cellular automata (QCA) is a novel and potentially attractive technology in nanometer scale and a possible alternative for CMOS. QCA has large potential in terms of high space density and power dissipation with the development of the high speed computer with low power consumption. This paper provides efficient design and layouts of digital circuits based on QCA using QCADesigner tool. The novel design provides the superior performance factors with respect to area, latency, circuit stability and low power dissipation. In this paper we present a number of new results on 2:1 and 4:1 multiplexers and detailed simulation using QCAD designer tool is presented.***

Index Terms— Multiplexer**, Quantum dot cellular automata, Quantum cell, QCAD tool.**

I. INTRODUCTION

Trusting on the unique properties of electronic devices at feature size of nano level, nanotechnology unlocks new prospects for computing systems and devices. QCA proposed by Lent et.al [1], is an emerging technology that offers an innovative approach for computing at nano-scale by monitoring the position of a single electron. QCA is an advanced research program and great efforts are made here to reduce the complexity of the circuit. The basic element of QCA is a quantum cell. QCA is visualized as a coupled dot system with four quantum dots at the corners of a square structure. Two free electrons are confined to any of two quantum dots[2]. Quantum dots are nanostructures created from standard semiconductive materials such as Si/SiO2[3]. QCA accomplishes the logic operations and the data flow occur in the circuit i.e. electron transmission occur by means of columbic interaction of the electrons of neighboring cells [4].

A.Quantum dot cellular automata:

Quantum dot cellular automata is a proposed physical implementation of classical cellular automata by exploiting quantum mechanical phenomena QCA have attracted a lot of attention as a result of its extremely small feature size i.e. at the molecular or even atomic scale and its ultra-low power consumption, making it as a candidate for replacing CMOS technology. QCA structures are designed as an array of quantum cells where every cell has electrons in them and electrostatic interaction with its neighboring cells take place [5]. QCA uses a new technique for computation. QCA uses polarization effect rather than conventional charge flow or current for the transmission of digital information [6]. Thus a quantum cell is responsible for the transfer of information throughout the circuit. The basic primitives used in QCA are three input majority gates, wire and an inverter [7, 8].

B.QCADesigner:

Quantum dot computer aided designer tool for cellular automata: QCA logic and circuit designers require a rapid and accurate simulation and design layout tool to determine the functionality of QCA circuits. QCADesigner gives the designer with the ability to quickly layout a QCA design by providing an extensive set of CAD tools[9]. As well, several simulation engines facilitate rapid and accurate simulation. It is the first publicly available design and simulation tool for QCA. It was developed at the ATIPS Laboratory, University of Calgary [10]. QCADesigner currently supports three different simulation engines, and many CAD features required for complex circuit . QCADesigner is an easy to use simulation and layout tool freely available to the research community via the Internet. One of the most important design specifications is that other developers are allowed to easily integrate their own utilities into QCADesigner. This is accomplished by providing a standardized method of representing information within the software.

II. Basics of QCA:

The basic elements of QCA are QCA cell, majority gate and inverter. In QCA cell each cell contains four quantum dots and two free electrons. The location of the electrons (polarization) determine the binary states[9]. Upon providing the clock the free electrons are charged and they occupy any of the two quantum dots in which are in diagonal positions. These two arrangements are denoted as cell polarization P=+1 and P= -1. We use cell polarization P

= +1 to represent logic "1" and P = -1 to represent logic "0". Binary information is encoded in charge configuration of the QCA cell.

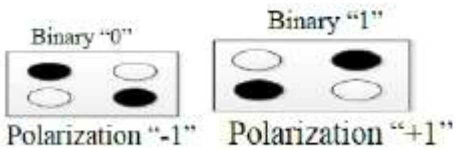

Figure 1. QCA cell polarizations

A. QCA cell:

A quantum-dot cellular automata (QCA) is a square nanostructure of electron wells having free electrons. Each cell has four quantum dots [5].The four dots are located in the four corners as shown above . The cell is charged with two free electrons. By using proper clocking mechanism, the electrons tunnel to proper location during the clock transition. The arrangement below gives the realization of inverter and majority gate using QCA.

QCA cells A, B and C are input cells, and M is the output cell that is polarized according to the polarization of the majority of the input cells. In this example, since two input QCA cells are polarized to +1, the output cell is also polarized to +1. QCA cells can also be used to construct wires.

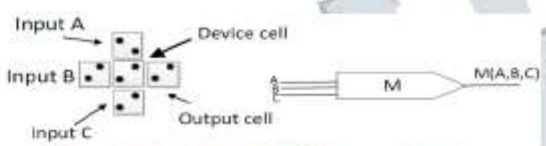

Figure 2. Majority gate

When an input is applied to the left input cell, the binary information propagates from the left to the right[11]. When all cells in a wire settle down to their ground states, they have the same polarization as shown in figure 2.3.

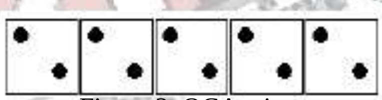

Figure 3. QCA wire

Two standard cells in diagonal orientation are geometrically similar to two rotated cells in horizontal orientation. Due to this, standard cells in diagonal orientation tend to align in opposite polarization directions. This antialligning behavior is used in designing a QCA inverter. The signal comes in from the left, splits into two parallel wires, and is inverted at the point of convergence. The design is geometrically symmetric as shown in figure 2.4.

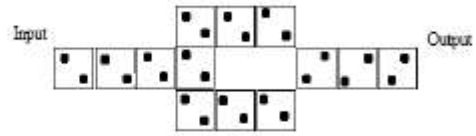

Figure 4. Inverter

A QCA design provides two options for crossover, termed as coplanar crossover and multilayer crossover. Coplanar crossover uses single layer but involves usage of two cell types (termed regular and rotated)and the multilayer crossover uses more than one layer of cells analogous to multiple metal layers in a conventional IC[7].

B. Clocking:

In QCA, circuits require a clock, not only to synchronize and control information flow but also to provide the power to run the circuit since there is no external source for powering cells. With the use of four phases clocking scheme in controlling cells, QCA processes and forwards information within cells in an arranged timing scheme[7]. Cells are grouped into zones so that the field influencing all the cells in the zones will be the same. A zone cycles through 4 phases.

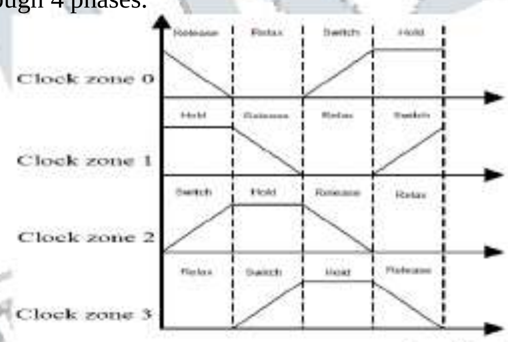

Figure 5.QCA clock zones and QCA clock with four phases.

In the switch phase electron tunneling is stopped as the tunnel barrier between the dots rising and due to the polarization of its input the electron in the cell become localized. During the hold phase as the barrier remains high no electron tunneling takesplace. The polarized cell is latched. Therefore, these cells are used as input to the next clock zone. During Release phase electrons become free and the cell starts to lose its polarization due to lowering of electron barrier. During the relax phase, the barriers are low, the electrons are free to tunnel and delocalize themselves and the cells will have no polarization i.e. P=0.

III.QCA IMPLEMENTATION OF MULTIPLEXERS

A. Implementation of basic gates:

The AND and OR gates are realized by fixing the polarization to one of the inputs of the majority gate to either P = −1 (logic "0") or P = 1 (logic "1")[9].

Figure 6. QCA layouts of AND gate and OR gate

B. Multiplexers implementation:

A multiplexer is a device that selects one of several input signals and forwards the selected input into a single line. A multiplexer of 2^n inputs has *n* select lines, which are used to select intended input line to send at the output end. Multiplexers are mainly used to increase the amount of data that can be sent over a particular network within a certain amount of time and bandwidth.

This paper provides QCA design of 2:1 multiplexer with single select line and 4:1 multiplexer with two select lines.2:1 multiplexers and 4:1 multiplexers are implemented using QCA designer tool as shown below.

Figure 7. QCA layout of 2:1 multiplexer

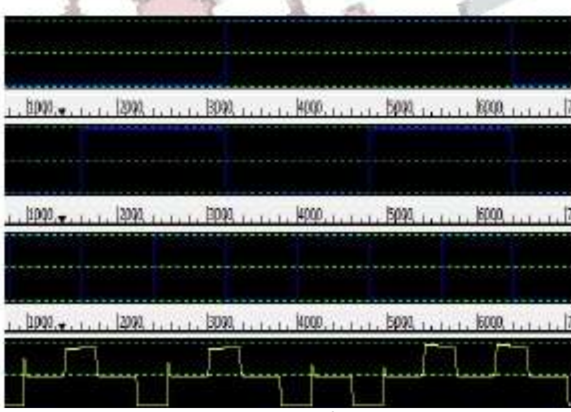

Figure 8.Simulation result for 2:1 multiplexer

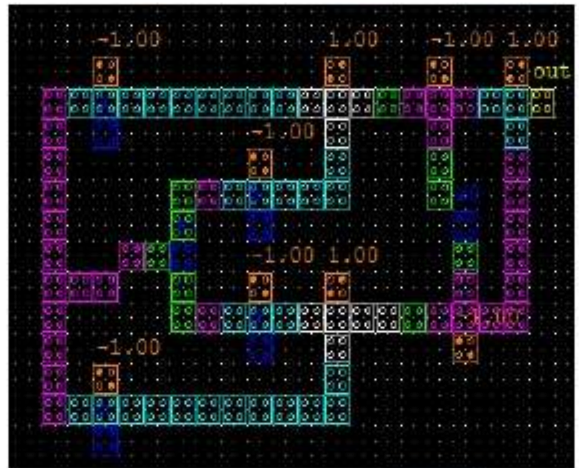

Figure 9. QCA layout of 4:1 multiplexer

Figure 10. Simulation result of 4:1 multiplexer

IV.RESULTS AND DISCUSSION

A.Comparative study of proposed design with some recent design layouts:

Here we have designed multiplexers which enable selection of single output signal from several input signals. The novelty of this design besides the parameters like area, usage efficiency, delay and complexity in terms of number of cells is minimal compared to some proposed designs in literature.

A table depicting comparative study of various parameters of proposed design of multiplexer is provided below.

	No. of cells	Area used(
As in[12] 4:1 Mux	138	0.14
As in[13] 2:1 Mux 4:1 Mux	22 107	0.03 0.14
Proposed design 2:1 Mux 4:1 Mux	23 98	0.03 0.12

Table 1. Comparative study of proposed design of multiplexer with some most recent design layouts

The tables of comparison depicts that the proposed design is efficient in terms of cell count, area usage and clocking.

IV.CONCLUSION

In this paper, we have considered the primitives in QCA and have presented efficient QCA designs for a 2:1 and 4:1and multiplexers. The paper provides the design, layout and simulation results of multiplexers using basic gates. The proposed implementation of circuits is simulated using QCA simulation tools, QCA Designer. The results of proposed design are compared with previous designs. The proposed design is found to be efficient in terms of cell count, area usage and clocking. Main advantage is, it requires a small simulation time and device execution time. By using quantum-dots in designing the circuits, it is possible to achieve miniaturization and high speed processing.

REFERENCES

[1]. Kunal Das and Debashis De, "Characterization, Test and Logic Synthesis of Novel conservative and Reversible Logic Gates for QCA", International Journal of Nanoscience, Vol. 9, No. 3, 201–214, 2010.

[2]. Pallavi A.N, Moorthy Muthukrishnan, "Implementation of Code Converters in QCAD",IJSRD, Vol. 2, Issue 06, 2014

[3]. M.Mustafa, M.R Beigh "Design and implementation of quantum cellular automata based novel parity generator and checker circuits with minimum complexity and cell count" Indian Journal of pure and applied physics, Vol. 51,PP 60-66,2013

[4]. Bibhash Sen ,Ayush Rajoria, Biplab K Sikdar, "Design of efficient full adder in Quantum dot cellular automata", The Scientific World Journal,vol.2013, article ID 250802

[5]. Lent C.S, Tougaw P.D, Porod W.D, and Bernstein G.H, "Quantum cellular automata,"Nanotechnology, vol.4, No.1, pp.49–57, 1993.

[6].

Bahram Dehghan, Ali Asghar Baziar, "Optimized Methodology for Realization of Logic Circuits using QCA Gates".IJARCSSE,vol 3,march 2013

[7]. Kodam. Latha,M. Nanda Maharshi, "Design of adders using qca",IJAET,Vol.6,Issue 4,ppp 1750 -1759,2013

[8]. Namit Gupta, Shantanu Shrivastava, Nilesh Patidar, Sumant Katiyal, Choudhary K K., "Design of One Bit Arithmetic Logic Unit (ALU) in QCA", International Journal of Computer Applications in Engineering Sciences,2012

[9]. S.Karthigai Lakhmi, G.Athisha, "International Journal for Computer Application",Vol.3, No-5, June 2010.

[10]. K.Walus, G.Jullien, "Design tools for an emerging soc technology: Quantum-dot cellular automata",IEEE proceedings,94(6),pp 1225-1244,June 2006

[11]. Kyosun Kim, Kaijie Wu, and Ramesh Karri, "The Robust QCA Adder Designs Using Composable QCA Building Blocks," IEEE transactions on computer-aided design of integrated circuits and systems, vol. 26, no. 1, pp 176-183, 2007.

[12]. E.N Ganesh,V.Krishnan, "Study and implementation of MUX based FPGA in QCA technology",International Journal of Distributed and Parallel Systems(IJDPS),Vol.2,No.3,May 2011

[13]. M. Kianpour, R.Sabbaghi - Nadooshan, "Optimized design of multiplexor by quantum-dot cellular automata" International Journal for Nanoscience and Nanotechnology, Vol.9, No.1, March 2013,pp.15-24.