ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 6, June 2014

Comparison of Complex Gates Using Quantum Dot Cellular Automata

Tina Suratkar[1]

Assistant Professor, Department of Electronics & Telecommunication Engineering, St.Vincent College of Engineering and Technology, Nagpur, Maharashtra, India [1]

ABSTRACT: This paper presents the basics of Quantum Dot Cellular Automata. In this paper two different complex gates such as 7-input complex gate and 5-input complex gate which are designed using QCADesigner tool are compared. An example of four input AND gate using 7-Input complex gate and 5-Input complex gate is taken and their simulation results are shown. All most all the parameters are considered while comparison. Hence it is shown that though the simulation results obtained using both the gates are same, still the 7-input complex gate is the most efficient one.

KEYWORDS: QCA, QCA cells, logic gates, complex gates, QCADesigner.

I.INTRODUCTION

The use of quantum-dots is a promising emerging technology for implementing digital systems at the nano-scale level. Recently studied computational paradigms for quantum-dot technology include the use of locally connected quantum-dot cellular automata (QCA). This technique is based on the interaction of electrons within quantum dots that take advantage of quantum phenomena; the same phenomena that may prove problematic in future integrated circuit technologies as feature sizes continue to decrease. The potential application in telecommunications technologies of QCA and the proposed devices is widespread and clear. By taking full advantage of the unique features of this technology, we are able to create complete circuits on a single layer of QCA. Such devices are expected to function with ultra-low power consumption and very high operating speeds[1].

The paper is organized as follows: The background of Quantum Dot Cellular Automata is described in section 2. Section 3 gives a brief idea regarding QCA clocking and QCA logic. In section 4, structure of 7-input complex gate is discussed and in section 5, structure of 5-input complex gate is discussed. In section 6, simulation results for four input AND gate using 7-Input and 5-Input complex gates has been given. Section 7 gives a comparison of both the complex gates and in section 8 conclusion is given.

II.QUANTUM DOT CELLULAR AUTOMATA

A QCA cell is a structure comprised of four quantum-dots arranged in a square pattern as shown in Fig 1.

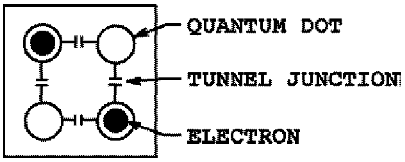

Fig. 1 QCA Cell

The quantum-dots within the cell provide 3D electron confinement and are capable of confining a controllable number of electrons. If the cell is charged with two excess electrons, they will tend to occupy antipodal sites as a result of their mutual electrostatic repulsion. These electrons are able to tunnel between dots if the potential barrier that separates the dots is low. Provided that the electrons will always tend to occupy antipodal sites, there are two possible configurations, which can be used to encode binary information as shown in Fig. 2.

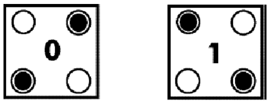

Fig. 2 Binary Encoding

Arrays of interacting QCA cells have been shown capable of all the logic functions required for universal digital design.1 QCA architectures have been proposed with potential barriers between the dots that can be controlled and used to clock QCA circuits.

Switching in QCA is accomplished by switching the occupancy of the two electrons. Signals are carried down arrays of QCA cells as a result of the interaction of adjacent cells. The topology of the QCA layout determines the interaction of the cells and hence the functionality of the overall circuit. The power consumption of QCA is low since only two electrons are moving. Most of the power required by QCA circuits will be used by the clocking scheme[2],[3].

III.QCA CLOCKING

The clocking of QCA can be accomplished by controlling the potential barriers between adjacent quantum-dots. When the potential is low the electron wave functions become delocalized resulting in no definite cell polarization. Raising the potential barrier decreases the tunneling rate, and thus, the electrons begin to localize. As the electrons localize, the cell gains a definite polarization. When the potential barrier has reached its highest point, the cell is said to be latched. Latched cells act as virtual inputs and as a result, the actual inputs can start to feed in new values. This enables easy pipelining of QCA circuits. It has been shown that four clocking zones each 90 degrees out of phase is all that is required by any QCA circuit as shown in Fig. 3.

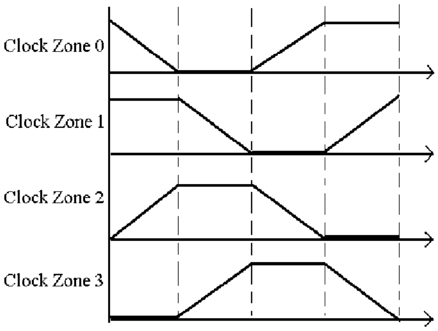

Fig. 3 QCA clocking zones

QCA Logic:

Adjacent QCA cells interact in an attempt to settle to a ground state determined by the current state of the inputs. This is most clear in the case of the QCA wire shown in Fig. 4.

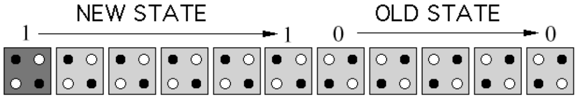

Fig. 4 QCA wire

The polarization of the input cell is propagated down the wire, as a result of the system attempting to settle to a ground state. Any cells along the wire that are anti-polarized to the input would be at a higher energy level, and would soon settle to the correct ground state.

Computation with QCA is accomplished by designing QCA layouts, which exhibit the desired interaction of states. Consider the arrangements in Fig. 5, demonstrating the QCA implementation of an inverter and a majority gate[4].

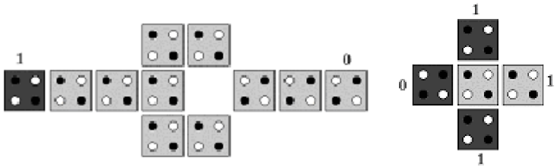

Fig. 5 Inverter and Majority gate

The ground state of the output cell of the above systems is a function of the shaded input cells and performs the desired logic function.

The majority gate is the fundamental QCA logic gate. The output cell will polarize to the majority polarization of the input cells. The Boolean expression for majority with inputs *a*, *b* and *c* is *m(a,b,c)=ab+bc+ca*. By fixing the polarization of any one of the inputs to the majority gate as logic 1 or logic 0, we obtain an OR gate or an AND gate respectively.

IV.7-INPUT COMPLEX GATE

Fig. 6 shows a 7-input gate. This gate is composed of three 3-input majority gates. Three of the inputs to this gate, e, f and g, function as control inputs that are used to specify the functionality of the circuit. The remain four inputs, a, b, c and d, are used to implement Boolean functions of four variables[6]. The functionality of this gate for all configurations has been simulated using QCADesigner[5].

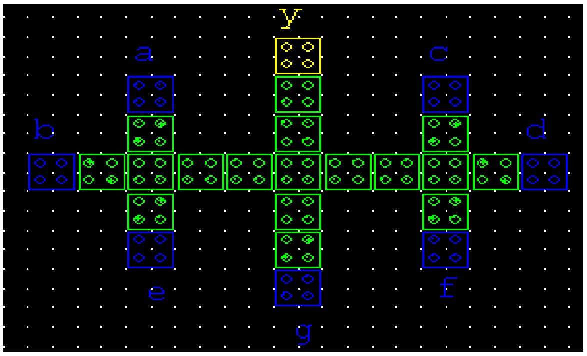

Fig. 6 7-Input Complex gate

In this gate when all the control inputs i.e e,f and g are placed at polarity +1 then this gate works as a four input OR gate. When the control inputs are placed at polarity -1 then this gate works as a four input AND gate. Different combinations of inputs give the realization of different functions.

V. 5-INPUT COMPLEX GATE

Fig. 7 shows a 5-input gate. This gate is composed of one 3-input majority gate. Input e, function as control input that is used to specify the functionality of the circuit. The remain four inputs, a, b, c and d, are used to implement Boolean functions of four variables[7]. The functionality of this gate for all configurations has been simulated using QCADesigner.

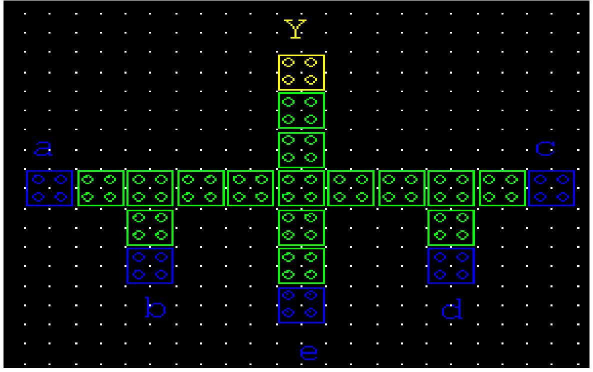

Fig. 7 5-Input Complex gate

In this gate when the control input e is placed at polarity +1 then this gate works as a four input OR gate. When the control input is placed at polarity -1 then this gate works as a four input AND gate.

VI.SIMULATION RESULTS

Let us consider an example of AND gate by restricting the inputs e, f and g in Fig. 6 and input e in Fig. 7 as having the polarity equals to -1. The simulation results obtained will be as shown in Fig. 8 and Fig. 9.

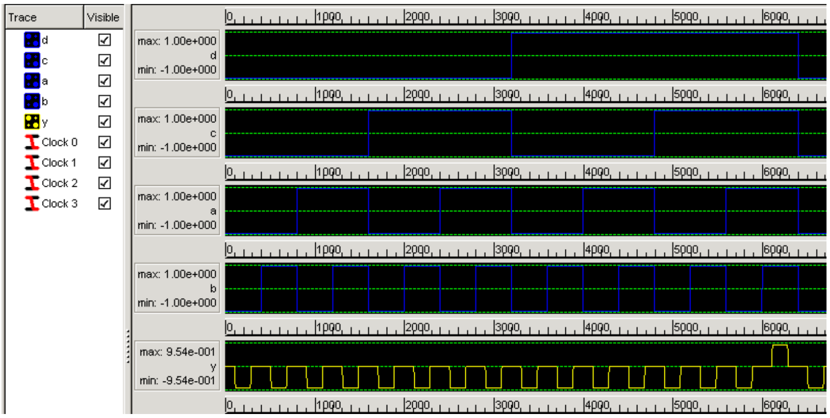

Fig. 8. Simulation results for four input AND gate using 7-Input complex gate

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 6, June 2014

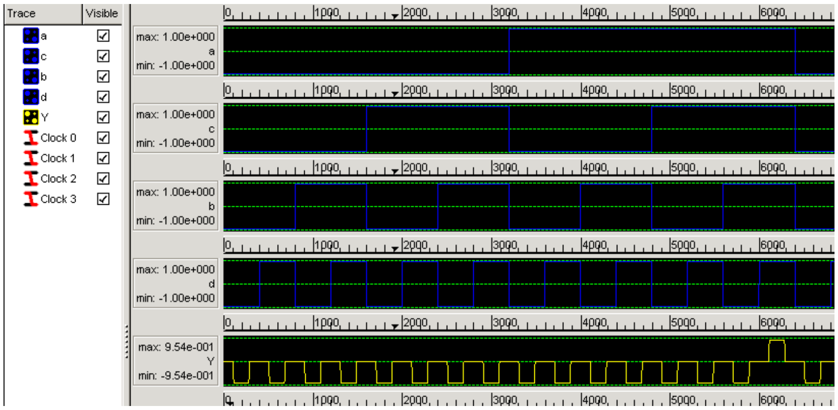

Fig. 9. Simulation results for four input AND gate using 5-Input complex gate

From the simulation results obtained from the two complex gates, we observe that the results obtained are identical. But there are certain points to be compared which will be discussed in section 7.

VII.COMPARISON

Following points in Table 1 give a comparison of two complex gates:

Point of comparison	7-Input Complex Gate	5-Input Complex gate
1. Number of cells	25	21
2. Number of majority gates	3	1
3. Execution time	2 sec	3 sec
4. Number of control inputs	3	1
5. Realization of other functions	Possible	Not possible

Table 1 Comparison between the two complex gates

VIII.CONCLUSION

From the table of comparison given in the section 7, it can be noticed that although the number of cells in 7-input Complex Gate is more still it is more efficient when execution time is considered. Apart from realizing four input AND gate and four input OR gate, the 7-input complex gate can realize other logical functions given in Table 1. Whereas 5-input Complex Gate can be used to realize four input AND gate and four input OR gate.

Thus we can conclude that the 7-Input Complex Gate is more efficient than the 5-Input Complex Gate.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 6, June 2014

REFERENCES

[1] A. Vetteth *et al.*, “Quantum-dot cellular automata carry-look-ahead adder and barrel shifter,” IEEE Emerging Telecommunications Technologies Conf., Richardson, TX, 2002.
[2] Tougaw, P.D., Lent, C.S., “Dynamic behaviour of quantum cellular automata”, *J. Appl. Phys*., American Institute of Physics, 80 (8) 4722, 1996.
[3] Timler, J., Lent, C.S., “Power gain and dissipation in quantum-dot cellular automata”, J.Appl. Phys., American Institute of Physics, 91 (2) 823, 2002.
[4] Hennessy, K., Lent, C., “Clocking of molecular quantum-dot cellular automata”, J. Vac. Sci.Technol., American Vacuum Society, B 19 (5) 1752, 2001.
[5] Walus, K. “QCADesigner Homepage”, http://www.atips.ca/~walus, ATIPS Laboratory, University of Calgary, Calgary, AB, 2002
[6] Townsend W.J and J.A.Abraham, “Complex Gate implementations for Quantum Dot cellular Automata,” *4th IEEE Conference on Nanotechnology*,pp.625-627, 2004.
[7] Tina Suratkar, “Five Input Complex Gate using Quantum Dot Cellular Automata”, IJAREEIE, Vol. 2, Issue 4, 940-944, April 2013