A Novel Approach To Design 4:2 Multiplexer Using Magnetic Quantum-Dot Cellular Automata

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Abstract- *Magnetic quantum-dot cellular automata (MQCA) is a latest technology in computation based on closely connected ferromagnetic and antiferromagnetic dots; it is expressing approval as the manufacturing issues arise day by day at the nanometer scale in CMOS technology. In this method first, we propose QCA based 2:1 Multiplexer using conventional agreeable parallel and perpendicular approaches. In the next step, we propose a novel area efficient condensed design approach with the help of the specific interaction, connected concept & dominant nature of slant edge nanomagnets. The proposed condensed design methodology leads to ∼78%- 94% reduction in the total number of nanodots and ∼20%- 98% reduction in area occupancy compared to the parallel, perpendicular, nanomagnetic QCA, and existing QCA-based 2:1 Mux. To show case the scalability of our proposed structure, we also execute an half adder, full adder, 4:2 Multiplexer. The design layouts and simulation results are verified using the using the qca designer 2.0.3 simulator. QCA Designer version 2.0.3 has been used for simulation. The simulation models of Half adder, Full adder, 2:1 and 4:2 multiplexer was designed are described.*

Keywords- Full adder, Multiplexer, QCA technology, nanomagnets.

I. INTRODUCTION

1.1OBJECTIVE OF THE PROJECT

Creating complete circuits on a single layer by reducing size and increasing switching speed. Simulation of the circuits can be done using QCA Designer version 2.0.3.Often (smaller) digital computing components today. Over the past few years the computing hardware industry and chip manufacturers in particular have tried to achieve these small scale hardware devices by almost a brute force scaling down of the involved components. Thus one saw the development of such things as TFTs (Thin Film Transistors) and a whole range of Thin Film Design innovations aimed only at one thing - to scale down the existing components and save space. In this process both success and failure were achieved. The success was an achievement of feature sizes of 60nm, and the development of commercial hardware such micro-controllers and processors built using such tiny devices. The failure was that the power leakage as device sizes shrunk down, started to grow exponentially. About 5 years ago, switching power leakage was so small that researchers almost neglected the issue completely but today with the tiny chips we have, power dissipation is a major headache. At feature sizes mentioned above, power loss due to switching alone is reaching values of up to 50%. However, the story does not end here, there are bigger evils to be tackled. Even if we were able to come up with schemes to ebb this loss of power, it would not success. The reason being the fact that as device dimensions scale down, the variation between two transistors produced by the same process becomes serious enough to hamper the scalability and hence the usability of the device. Perhaps even more threatening is the fact that Quantum effects are beginning to show up now. Going any further below this scale would require researchers to develop knowledge about high power losses and building up and controlling very large Electric Fields capable of damaging the device. To add to this, quantum mean a very high probability of electrons tunneling through the wires and other devices thus creating more troubles for the already troubled scientists. The time is therefore apt, to look elsewhere for newer ways of doing things, in short to look beyond silicon. In Quantum this report starts by rest delving into some quantum mechanics and in particular talking about quantum dots. We then introduce the concept of a Quantum Cellular Automata and the various interesting properties it displays. We then move on to the design of basic building blocks of digital circuit design using Quantum Cellular Automata wherein we explore some things such as quantum wires, inverters and majority gates. After looking at some of these basic designs, we go on to explore the concept of clocking with reference to Quantum Cellular Automata and the build-up of very basic synchronous machinery in terms of a shift register. We then discuss a couple of large regular designs such as ROMs and FPGAs that may potentially be built using these automata. Finally, we describe our own efforts toward extending the work in synchronous circuits using QCA's wherein we discuss some synchronous modules we had success in creating and also discuss some difficulties experienced in the same.

1.2. INTRODUCTION TO QUANTUM CELLULAR AUTOMATA (QCA)

Quantum Cellular Automata (QCA) refers to models of quantum computation, which have been devised in analogy to conventional models of cellular automata introduced by von Neumann. It may also refer to quantum dot cellular automata, which is a proposed physical implementation of "classical" cellular automata by exploiting quantum mechanical phenomena. QCA has attracted a lot of attention as a result of its extremely small feature size (at the molecular or even atomic scale) and its ultra-low power consumption making it one candidate for replacing CMOS technology. In QCA, a quantum cell normally consists of four quantum dots at the corners of a square pattern, with two excess electrons that are free to tunnel between the dots but which cannot leave the cell. Due to Coulomb repulsion, these two electrons tend strongly to occupy diagonally opposite dots. In a second type of QCA cell, the dots are located at the middle of the sides of the cell, instead of at the corners. In either cell type, there are just two configurations with energetically equivalent polarizations designated as +1 and −1. This means that quantum cells can be employed as binary systems to represent logical true and false (or digital 1 and 0). Moreover, multiple quantum cells can be arranged in various linear formations to produce logic gates, which can in turn be used to build devices for computation. The basic logic elements in QCA logic are the majority gate and the inverter(or NOT gate).

II. LITERATUREREVIEW

2.1 Quantum Cellular Automata: The Physics of Computing with Arrays of Quantum Dot Molecules

AUTHOR: Craig. S. Lent, P. Douglas Tougaw, and Wolfgang Porod

The fundamental limits of computing using a new paradigm for quantum computation, cellular automata composed of arrays of coulombically coupled quantum dot molecules, which we term quantum cellular automata (QCA). Any logical or arithmetic operation can be performed in this scheme. QCA's provide a valuable concrete example of quantum computation in which a number of fundamental issues come to light. We examine the physics of the computing process in this paradigm. We show to what extent thermodynamic considerations impose limits on the ultimate size of individual QCA arrays. Adiabatic operation of the QCA is examined and the implications for dissipation less computing are explored.

2.2 QCADesigner: A Rapid Design and Simulation Tool for Quantum-Dot Cellular Automata

Author: KonradWalus, Timothy J. Dysart, Graham A. Jullien, and R. AriefBudiman

This paper describes a project to create a novel design and simulation tool for quantum-dot cellular automata (QCA), namely QCA Designer. QCA logic and circuit designers require a rapid and accurate simulation and design layout tool to determine the functionality of QCA circuits. QCA Designer gives the designer the ability to quickly layout a QCA design by providing an extensive set of CAD tools. As well, several simulation engines facilitate rapid and accurate simulation.

III. METHODOLOGY

QUANTUM DOTS

Quantum dots are semiconductors that are on the nano meter scale. Obey quantum mechanical principle of quantum confinement. Exhibit energy bad gap that determines required wave length of radiation absorption and emission spectra. Requisite absorption and resultant emission wavelength dependent on dot size.

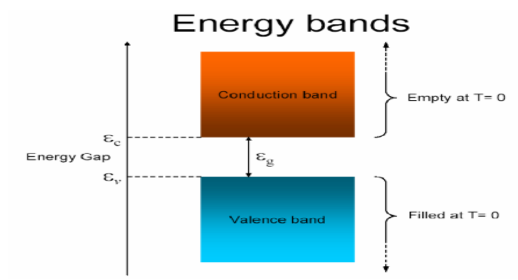

Fig.1 The energy band gap associated with semi-conducting materials

The Basic QCA Logical Device - The Majority Gate The fundamental QCA logical circuit is the three-input majority gate that appears in Figure 3.2. Computation is performed with the majority gate by driving the device cell (cell 4 in the figure) to its lowest energy state. This happens when it assumes the polarization of the majority of the three input cells. We define an input cell simply as one that is changed by a signal that is propagating in a direction that is toward the device cell. The device cell will always assume the majority polarization because it is this polarization. Where electron repulsion between the electrons in the three input cells and the device cell will be at a minimum. It can be electron has latched to the barrier potential. When should be latched to that increase in inner dot barriers. For example of three inputs are cell 1, cell 2, and cell 3. The cell 4 is device cell (it is a fixed polarization) the fixed polarization is two categories such as the fixed polarization is -1 that is AND gate operation and the fixed polarization is +1 that is OR gate operation. The majority gate three input operation has combined to both (AND and OR) operation. The bit value 0 that is called as polarization of -1 and the bit value 1 that is called as polarization of +1. To understand how the device cell reaches its lowest energy state (and hence P=+1 in Figure 2.2), consider the columbic interaction between cells 1 and 4, cells 2 and 4, and cells 3 and 4. Columbic interaction between electrons in cells 1 and 4 would normally result in cell 4 changing its polarization because of electron repulsion (assuming cell 1 is an input cell). However, cells 2 and 3 also in quenching the polarization of cell 4 and have polarization P=+1. Consequently, because the majority of the cells in Quenching the device cell have polarization P=+1, it too will also assume this polarization because the forces of columbic interaction are stronger for it than for P=1.

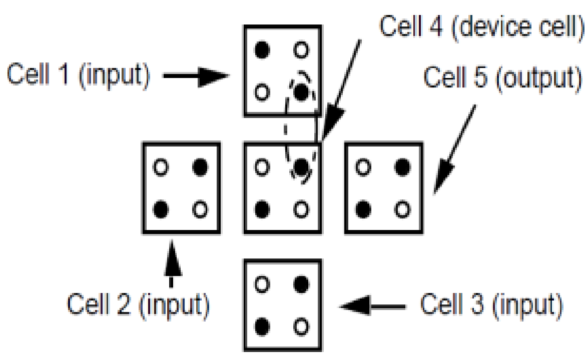

Fig.2 The fundamental QCA logical device - the majority gate

1V. SIMULATION RESULTS

4.1HALF ADDER

Half adder consist of two binary inputs and two binary outputs. The input variables designate the augend and addend bits; the output variables produce the sum and carry.

S = A’B + AB’

= AB

Expression for Sum:

Sum = A_bar&B + B_bar& A = (A & B)_bar & (A + B)

Let us have X = (A & B)_bar= majority(A, B, ‘ 0 ’)

and Y = (A + B) = majority (A, B, ‘1’)

Therefore X * Y =majority (X, Y, ‘0’) = Sum = majority ([majority(A, B, ‘ 0 ’)],[majority (A, B, ‘1’)], ‘0’)

Carry = X = (A& B) =majority(A, B,‘ 0 ’)

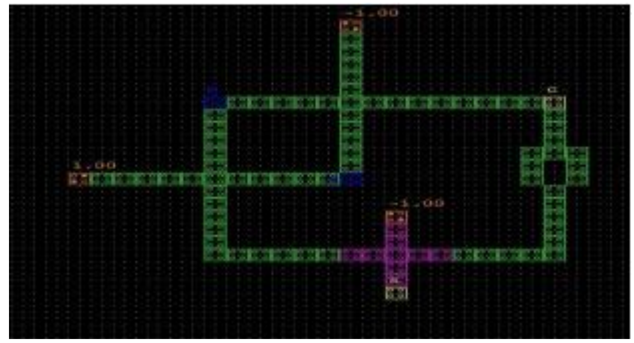

Fig.3 Simulation circuit of Half Adder

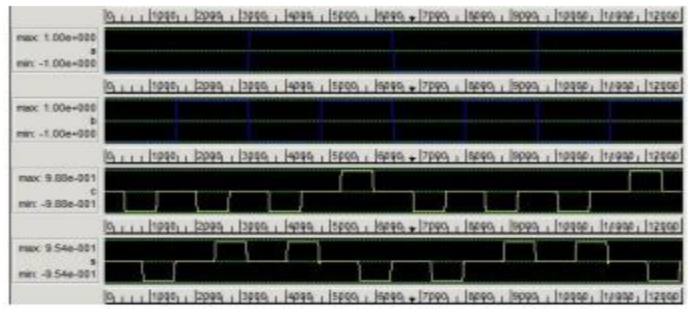

Fig.4 Simulation output of Half Adder

4.2 MULTIPLEXER

Multiplexing means transmitting a large number of information over a smaller number of channels or lines. A digital multiplexer (data selector) is a combinational circuits that selects binary information from one of many input lines and directs it to a single output line. With two input signals and one output signal, the device is referred to as a 2-to-1 multiplexer; with four input signals it is a 4-to-1 multiplexer; etc.

Expression of multiplexer:

Y=majority([majority(D0,A’,B’,0),majority(D1A’,B,0),majority(D2,A,B’,0),majority(D3,A,B,0),],1)

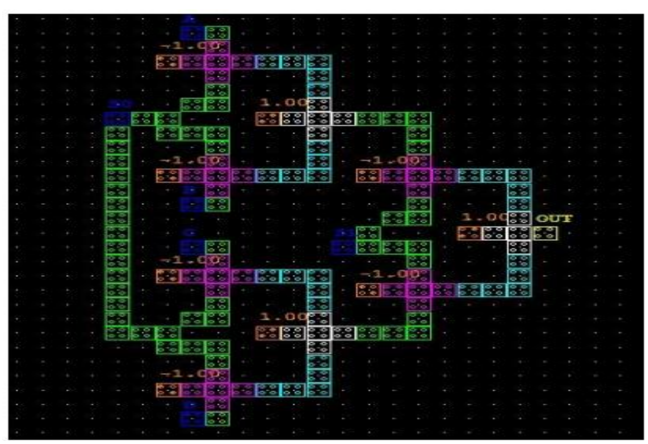

Fig.5 Simulation circuit of 4:2 Multiplexer

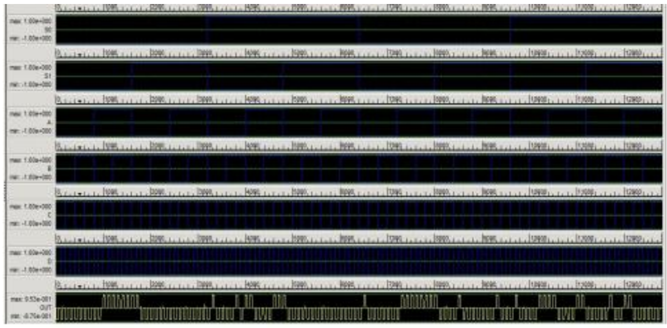

Fig.6 Simulation output of 4:2 Multiplexer

V. CONCLUSION

QCA is expected to achieve high device density, extremely low power consumption and very high switching speed. Half adder, Full adder, 2:1 and 4:2 multiplexer was designed in QCA Designer and the simulation result was obtained. The design has 124 cells (including input and output cells) and area of approximately 0.25μm^2. Future work will extend to design the Digital circuits such as demultiplexer and counter.

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