A Methodology for Standard Cell Design for QCA

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Outline

• Introduction
  – QCA
    – Clocking zones
    – Clocking schemes

• Proposed Clocking Schemes

• QCA ONE
  – Cells
  – Results

• Conclusion
Quantum-Dot Cellular Automata - QCA

Paradigm of digital logic circuits for computing. Nanoscale; Information is transmitted without the flow of electric current (Coulomb Interaction); fast; low power dissipation.

Binary 1
Polarization 1

Binary 0
Polarization -1
Quantum-Dot Cellular Automata - QCA

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Quantum-Dot Cellular Automata - QCA

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QCA Wire
Quantum-Dot Cellular Automata - QCA

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Quantum-Dot Cellular Automata - QCA

Majority Gate

Input 1

Input 2

Input 3

output
Clocking Zone, Phase and Cycle

- Allows *adiabatic switching* (energy efficient)
- 1 Clock cycle 4 phases

  - Phase 1 – **Switch**: the cells can polarize;
  - Phase 2 – **Hold**: the polarization of the cell can’t change;
  - Phase 3 – **Release**: the cells depolarize;
  - Phase 4 – **Relax**: the cells still depolarized.

**Time step 0**

Clock zone 0 in switch phase
Clock zone 1 in relax phase
Clock zone 2 in release phase
Clock zone 3 in hold phase
Clocking Zone, Phase and Cycle

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Clock zone 0 in relax phase  
Clock zone 1 in release phase  
Clock zone 2 in hold phase  
Clock zone 3 in switch phase
Free clocking scheme

- Colors define clocking zones;
- Designer defines the clocking zones;
- There is no clock standard;
- Does not work in molecular or magnetic (nanomagnet logic - NML) QCA.
Linear clocking scheme

No feedback!


Shape clocking scheme

Zones have different sizes and shapes!

Hard clock circuit implementation

There are more zones 1 and 3 than 2 and 4!

2DDWave clocking scheme

USE clocking scheme

USE clocking scheme

QCA ONE

- QCA Standard Cells;
- Using USE clocking scheme
  - Regular shape;
  - Enable placement & routing.
Inverter

name: inv # cell name
n_input: 1 # number of inputs
n_output: 1 # number of outputs
input: in # list of inputs
output: out # list of outputs

expression: # expression corresponding to the function performed
out = ~in

zone_dimension: 5 # dimension of USE zone in terms of QCA cells

width: 5 # width in number of QCA cells
height: 5 # height in number of QCA cells
layers: 1 # number of layers used
l_reference_zone: 1 # left reference zone
r_reference_zone: 2 # right reference zone

delay_table: # table of delays between each pair input/output
/ in
out 0

port_location: # coordinates for input and output ports
in 0 2 0
out 4 2 0

free:
QCA ONE - Results

One bit full adder
QCA ONE - Results

8 bits
Ripple
Carry Adder
Conclusion & Future Works

- We proposed and implemented a QCA standard cell library;
- We presented some no optimized circuits implemented with the cells;
- Placement and routing must be developed;
- More cells are being created;
- A QCADesigner with USE and QCA ONE will released;
- Clocking schemes and standard cells library will be implemented to NML.