REVERSIBLE LOGIC GATES AND THEIR APPLICATIONS

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Abstract **Reversible logic is one of the most vital issue at present time and it has different areas for its application, those are low power CMOS, quantum computing, nanotechnology, cryptography, optical computing, DNA computing, digital signal processing (DSP), quantum dot cellular automata, communication, computer graphics. It is not possible to realize quantum computing without implementation of reversible logic. The main purposes of designing reversible logic are to decrease quantum cost, depth of the circuits and the number of garbage outputs. This paper provides the basic reversible logic gates, which in designing of more complex system having reversible circuits as a primitive component and which can execute more complicated operations using quantum computers. The reversible circuits form the basic building block of quantum computers as all quantum operations are reversible. This paper presents the data relating to the primitive reversible gates which are available in literature and helps researches in designing higher complex computing circuits using reversible gates.**

Keywords— Reversible logic, Reversible gate, Power dissipation, Garbage, Quantum cost, Quantum-dot Cellular Automata, Reversible Computing.

I. INTRODUCTION

The variable frequency inverters area unit utilized in wide applications particularly 3 section induction motor drive Everyday new technology which is faster, smaller and more complex than its predecessor is being developed.

The increase in clock frequency to achieve greater speed and increase in number of transistors packed onto a chip to achieve complexity of a conventional system results in increased power consumption. Almost all the millions of gates used to perform logical operations in a conventional computer are irreversible. That is, every time a logical operation is performed some information about the input is erased or lost and is dissipated as heat.

Energy dissipation is one of the major issues in present day technology. According to Landauer's[1] principle, the loss of one bit of information lost, will dissipate kT*ln (2) joules of energy where, k is the Boltzmann's constant, T is the absolute temperature . In 1973, Bennett [2], showed that in order to avoid kTln2 joules of energy dissipation in a circuit it must be built from reversible circuits. According to Moore's law the numbers of transistors will double every 18 months. Thus energy conservative devices are the need of the day. The amount of energy dissipated in a system bears a direct relationship to the number of bits erased during computation. Reversible circuits are those circuits that do not lose information. The current irreversible technologies will dissipate a lot of heat and can reduce the life of the circuit. The reversible logic operations do not erase (lose) information and dissipate very less heat. Synthesis of reversible logic circuit differs from the combinational one in many ways.

Firstly, in reversible circuit there should be no fan-out, that is, each output will be used only once.Secondly for each input pattern there should be unique output pattern. Finally, the resulting circuit must be acyclic. Any reversible circuit design includes only the gates that are the number of gates, quantum cost and the number of garbage outputs.

II. BASIC DEFINITIONS PERTAINAING TO REVERSIBLE LOGIC GATES

A. Reversible Function: The multiple output Boolean function F(x1; x2; :::; xn) of n Boolean variables is called reversible if:

a. The number of outputs is equal to the number of inputs;

b. Any output pattern has a unique pre-image.

B. Reversible logic gate:Reversible Gates are circuits in which number of outputs is equal to the number of inputs and there is a one to one correspondence between the vector of inputs and outputs[8-10]. It not only helps us to determine the outputs from the inputs but also helps us to uniquely recover the inputs from the outputs.

C. Ancilla inputs/ constant inputs :This refers to the number of inputs that are to be maintain constant at either 0 or 1 in order to synthesize the given logical function[11].

D. Quantum cost:Quantum cost refers to the cost of the circuit in terms of the cost of a primitive gate. It is calculated knowing the number of primitive reversible logic gates (1*1 or 2*2) required to realize the circuit. The quantum cost of a circuit is the minimum number of 2*2 unitary gates to represent the circuit keeping the output unchanged. The quantum cost of a 1*1 gate is 0 and that of any 2*2 gate is the same.

E. Flexibility :Flexibility refers to the universality of a reversible logic gate in realizing more functions

III. REVERSIBLE GATES

Some of the important reversible logic gates are:

•2.1 NOT Gate

The simplest Reversible gate is NOT gate and is a 1*1 gate [21]. The Reversible 1*1 gate is NOT Gate with zero Quantum Cost is as shown in the Figure 1.

Fig 1: NOT Gat

• 2.2 CNOT Gate

CNOT gate is also known as controlled-not gate. It is a 2*2 reversible gate. The CNOT gate can be described as: Iv = (A, B) ; Ov = (P= A, Q= A^B) Iv and Ov are input and output vectors respectively. Quantum cost of CNOT gate is 1[22]. Figure 2 shows a 2*2 CNOT gate and its symbol.

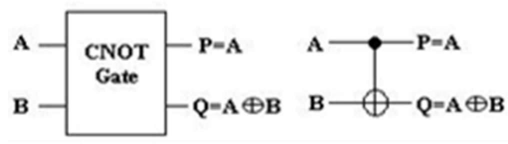

Fig 2: CNOT gate

• 2.3 Feynman Gate

The Feynman gate which is a 2*2 gate and is also called as Controlled NOT and it is widely used for fan-out purposes. The inputs (A, B) and outputs P=A, Q= A XOR B. It has quantum cost one [23].

Fig 3: Feynman gate

• 2.4 Toffoli Gate

Fig 4 shows a 3*3 Toffoli gate. The input vector is I (A, B, C) and the output vector is O(P,Q,R). The outputs are Fig 4 shows a 3*3 Toffoli gate. The input vector is I (A, B, C) and the output vector is O(P,Q,R). The outputs are defined by P=A, Q=B, R=AB □C. Quantum cost of a Toffoli gate is 5[5].

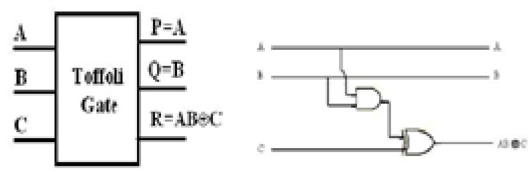

Fig 4: Toffoli gate

• 2.5 Fredkin Gate

Fig 5 shows a 3*3 Fredkin gate. The input vector is I (A, B, C) and the output vector is O (P, Q, R). The output is defined by P=A, Q=A′B□AC and R=A′C□AB. Quantum cost of a Fredkin gate is 5[6].

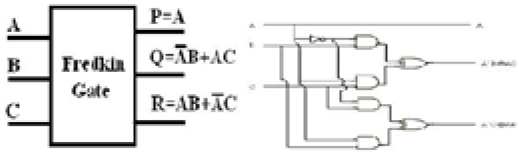

Fig 5: Fredkin Gate

IV. PROBLEMS WITH REVERSIBLITY

•However, in order to attain the supposedbenefits of reversible computation, thereversible machine must actually be runbackwards to attain its original state. If this step is not taken, then typically the machinebecomes clogged up with digital heat i.e.entropy, and is thus rendered unable to performfurther useful work.
•Another problem is that you must make sureyour computation was perfomed with no errors otherwise chaos (and not the original startingcondition) may result when the machine is run backwards.
•Without running a reversible machinebackwards, the main benefits of usingreversible logic - namely dramatically reducedheat dissipation and power consumption - cannot be realized in a sustainable fashion.

 Benefits of reversible gates:
Reversible logic allows in the digital domain.
1) Power Management
2) Heat Management

V. APPLICATIONS OF REVERSIBLE GATES

Reversible computing may have applications in computer security and transaction processing, but the main long-term benefit will be felt very well in those areas which require high energy efficiency, speed and performance .it include the area like

- Low power CMOS.
- Quantum computer.
- Nanotechnology.
- Optical computing.
- DNA computing.
- Computer graphics.
- Communication.

The potential application areas of reversible computing include the following
• Nano computing
• Bio Molecular Computations
• Laptop/Handheld/Wearable Computers
• Spacecraft
• Implanted Medical Devices
• Wallet “smart cards”
• Prominent application of reversible logic lies in quantum computers.
• Quantum gates perform an elementary unitary operation on one, two or more two–state quantum systems called qubits.
• Any unitary operation is reversible and hence quantum networks also.

VI. CONCLUSION

The reversible circuits form the basic building block of quantum computers. This paper presents the primitive reversible gates which are gathered from literature and this paper helps researchers/designers in designing higher complex computing circuits using reversible gates. The paper can further be extended towards the digital design development using reversible logic circuits which are helpful in quantum computing, low power CMOS, nanotechnology, cryptography, optical computing, DNA computing, digital signal processing (DSP), quantum dot cellular automata, communication, computer graphics.

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