

Survey of Reversible Logic: A Review

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Abstract—A new study on reversible logic that ensures a continuous tendencies in the development of ideas discover and utilise resources. Researchers are looking on reversible logic to address the power dissipation issue. Design with low power is a desirable feature for a variety of applications, IoTs and quantum computing. The reversible gate offers a wide range of applications, including quantum computing, optical, low-power CMOS and so on. This paper gives a review of relative circuit study using various reversible gates. Each unique input combination, reversible logic circuits provide a unique output, and vice versa. This document includes a description of the work done as well as numerous factors. Reversible logic is used to increase speed, reduce energy consumption, lower quantum cost, and reduce the amount of trash outputs and circuit depth. And minimise the amount of trash outputs and circuit depth the logic is reversible.

Index Terms— Reversible gate, Reversible logic, Quantum cost and trash outputs.

I. INTRODUCTION

In the design of digital circuits, the main concern is for heat dissipation. This concern is including both customers and producers of the digitized circuits. Due to energy dissipation, there is increase in the loss of information. Because of its potential of saving energy dissipation, the concept of reversible logic [49] has seen a lot of application in low power digital circuit design in the last 10 years. Rolf Landauer et al. calculates the quantity of energy lost to every single bit operation. [1], and the magnitude of energy dissipation, according to Rolf Landauer, is at least $kT \ln 2$ joules.

II. LITERATURE SURVEY

Physical reversibility is associated to logical reversibility, that needs a low level of thermal value each machine cycle, according to R. Landauer [1], who stated that non-reversible logic calculations must generate, With each piece of knowledge lost, the thermal energy is equal to $kT \ln 2$ joules, in which k is the Boltzmann constant. Although amount of heat dissipation is tiny, it cannot be ignored. At the moment, heat dissipation of this magnitude may be overlooked, but in the future, it will be impossible to do so. Moore [2] projected in 1965 that most every two years or so, the transistor count on a device would quadruple. Moore's law is the name given to this phenomenon. As a result of this equation, as the number of components on a chip grows, so does the amount of power dissipated. The chip's heat evaporated is equal to the quantity of power dissipated. As a result, the key factor is power dissipation. As a result, it should be lowered. In addition, in 1973, C.H. Bennett [3] claims that if a computation is performed in reversible logic, zero energy dissipation is conceivable since the quantity of energy dissipated in the system is proportional to the number of bits erased during the computation. For no information

loss circuits, reversible logic is best suited. Designing of reversible circuits is done with various reversible gates. Efficiency of the circuit will not be effected due to use of reversible logic gates. Fredkin reversible gate was introduced by Edward Fredkin [4]. Another new reversible gate was Toffoli gates, which was introduced by Tommaso Toffoli in 1980's [5]. Both Fredkin and Toffoli gates work on reversibility. Both gates are called universal gates. These gates are having three inputs and three outputs. So these gates are 3*3 reversible gates. Power dissipation is near to zero in these gates. A nonuniversal gate called Peres gate was familiarized by Peres in 1985[6]. This gate has less quantum cost. Due to less quantum cost of this gate as compared to universal gates, it is extensively used. An algorithm which runs on quantum computer was described, which runs on reversible logic [7]. An approach of implementing latch with less number of gates and garbage output is given [8]. Paper by S. Chiwande Prashant R. Yelker, describes circuits which are implemented by using reversible logic gates. An approach was given to reduce the garbage output of the reversible gate circuits by N Ranganathan and H Thalpiyal [10]. Few circuits were implemented using reversible gates like Feynman and fredkin gate [11]. The paper by V. Ranganathan and V. Raj Mohan, described the design of counters with reversible gates [12]. Reversible gates were also used for designing ALU [13]. Combining reversible logic gates to conduct sophisticated logical and arithmetic operations produces reversible circuits [50].

II. REVERSIBLE GATE

A reversible gate is a circuit having n inputs and n outputs. These circuits have a one-of-a-kind input-output mapping. [51].

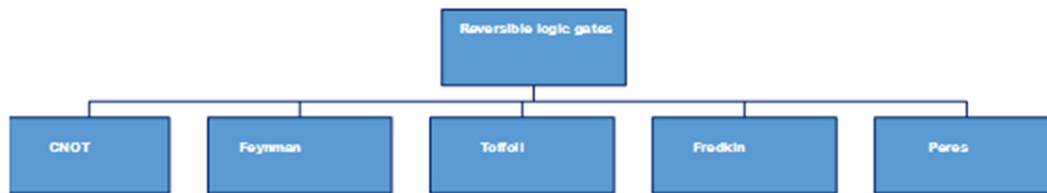


Figure 1. Note Numerous Reversible gates

A. Reversible logic

In reversible logic circuits constructed using reversible logic gates, the input and output vectors have a one-to-one mapping. In reversible logic circuits, inputs can be created from outputs, which means that Output vectors can be used to rebuild input vectors.

Reversible Gate: The number of inputs and outputs on a reversible gate is the same as a unidirectional gate. As a result, we may claim that the number of inputs equals the number of outputs for these gates. The input and output are mapped one to one [17]. The following are some terminology that are used in reversible logic circuits:
Quantum Cost: The quantity of 1x1 and 2x2 reversible gates or quantum gates used in the design of a reversible gate is known as its quantum cost.

Ancilla Input: The addition of extra constant state qubits to the reversible circuit to get reversibility are called Ancilla Inputs.

Constant input: The term "constant input" refers to inputs which are always the same. As a result, they can have a value of 1 or 0.

Garbage Outputs: The circuit's outputs that's not in use are called unused outputs also referred to as GO.

Reversible Gates of Numerous Forms are: Reversible gates, which are invented are described in detail below:

NOT Gate: It is uncomplicated gate. It has a single input and output. It comes at no cost in terms of quantum. The NOT gate with input A and output P is shown in the diagram below.



Figure 2. A NOT gate

CNOT Gate: The CNOT gate is a NOT gate that is controlled. It has two inputs and two outputs. Quantum cost of this is one. It is pictured below.



Figure 3. CNOT gate

Feynman Gate: Controlled NOT gate is another name for it. There are two inputs and two outputs on it. Below Fig. shows Feynman gate.



Figure 4. Feynman gate

Toffoli Gate: This device has three inputs and three outputs. The Toffoli gate is seen in diagram below.

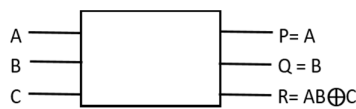


Figure 5. Toffoli Gate

Fredkin gate: There seem to be 3 inputs and 3 outputs. The quantum cost of a Fredkin gate is Five. It is seen in the diagram below.

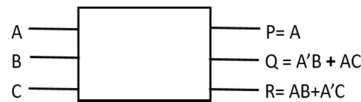


Figure 6. Fredkin gate

Peres Gate: Three inputs and three outputs are gated by Peres. Below Fig. shows Peres gate.

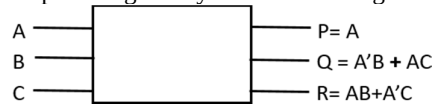


Figure 7. Peres gate

B. Relative Study of Reversible logic Circuits

Chart 1, below indicates various parameters for reversible gates.

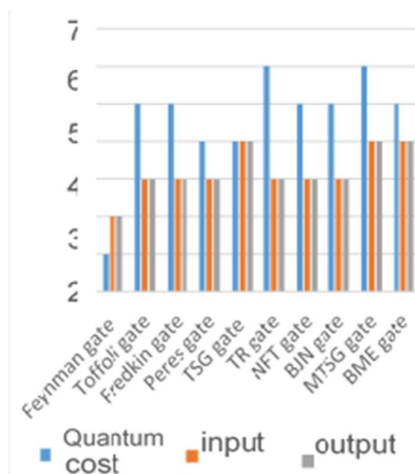


Chart 1: Various parameters for reversible gates

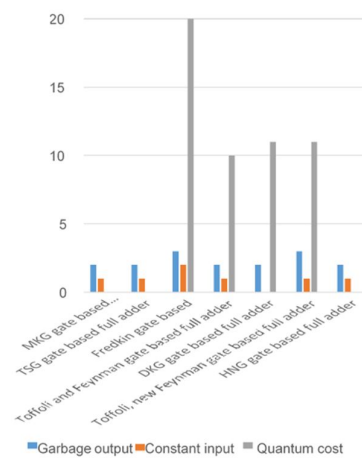


Chart 2. Full adder using various reversible gates

Above chart 1 shows Quantum cost, the quantity of inputs and outputs for various Reversible gates. Feynman gate [24], Toffoli gate [22], Fredkin gate [5], Peres gate, and other reversible gates are analyzed. Now a days, various circuits like alu, adders, filters, subtractors, multiplexers, counters, registers, etc. In chat 2, The numerous reversible gates that build up a full adder are shown in Chart 2. MKG reversible gate is used in a full adder has Garbage output 2, Gate Count1, Constant input1, Quantum cost not defined [29]. Full adder using TSG gate has Garbage output2, Gate Count1, Constant input 1, Quantum cost not defined. Full adder using Fredkin gate has Garbage output3, Gate Count4, Constant input 2, Quantum cost 20. Full adder using Toffoli and Feynman gate has Garbage output2, Gate Count4, Constant input 1, Quantum cost 10. Full adder using DKG gate has Garbage output2, Gate Count not defined, Constant input not defined, and Quantum cost 11. Full adder using DKG gate has Garbage output3, Gate Count3, Constant input 1, Quantum cost 11. Full adder using HNG gate has Garbage output2, Gate Count 1, Constant input 1, Quantum cost not defined.

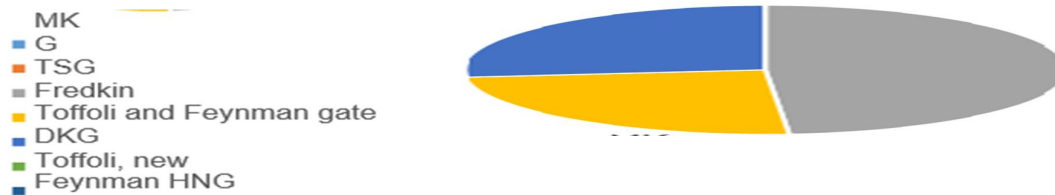


Chart 3. Full adder Quantum cost for various reversible gates

III. CONCLUSIONS

In this paper our main aim was to do a survey on Reversible logic. Reversible logic gates have evolved as one of the most effective ways for today's electronic gadgets to reduce the amount of power consumed by high-speed architecture.

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