**CHAPTER-3**

**REVERSIBLE GATES**

# 3. REVERSIBLE GATES

**3.1 INTRODUCTION**

Reversible logic is being considered as an alternative of traditional irreversible logic since reversible computing does not erase or lose any information. As a result, reversible logic has a theoretical potential to dissipate no energy. According to Frank, reversible logic can recover a fraction of energy that can reach up to 100%. As there is no limit in reducing the heat dissipation in reversible logic, the amount of dissipated heat will become 1 very close to zero with the development of hardware. Reversible logic is a vital part of quantum computing since quantum computation is reversible, and the physical reality of quantum logic can be illustrated by reversible logic. Reversible computing is also useful for other technologies including low power CMOS design, optical computing, nanotechnology, and bioinformatics.

**3.1.1 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.

**3.1.2 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. It not only helps us to determine the outputs from the inputs, but also helps us to uniquely recover the inputs from the outputs.

**3.1.3 ANCILLA INPUTS/ CONSTANT INPUTS:**

This refers to the number of inputs that are to be maintained constant at either 0 or 1 in order to synthesize the given logical function.

**3.1.4 GARBAGE OUTPUTS:**

Additional inputs or outputs can be added so as to make the number of inputs and outputs equal whenever necessary. This also refers to the number of outputs which are not used in the synthesis of a given function. In certain cases these become mandatory to achieve reversibility.

**3.2** **BASIC REVERSIBLE GATES:**

There are many number of reversible logic gates that exist at present. Some of the important reversible logic gates are

**3.2.1** **NOT GATE**:

The simplest Reversible gate is NOT gate and is a 1\*1 gate.

NOT

GATE

A

P =

**Fig. 1 Block diagram of NOT gate**

**3.2.2 FEYNMAN GATE:**

The Feynman gate which is a 2\*2 gate and is also called as Controlled NOT, is widely used for fan-out purposes. The inputs are (A, B) and outputs are P=A, Q= A XOR B.

FEYMAN

GATE

A

B

P = A

Q = A⊕B

**Fig. 2 Block diagram of Feynman gate**

**3.2.3 FREDKIN GATE:**

Fredkin gate is a 3\*3 gate with inputs (A, B, C) and outputs P=A, Q=A'B+AC, R=AB+A'C

FREDKIN

GATE

A

B

C

P = A

Q = B+AC

R = AB+C

**Fig. 3 Block diagram of Fredkin gate**

**3.2.4 PERES GATE:**

Peres gate is a 3\*3 gate having inputs (A, B, C) and outputs P = A; Q = A XOR B; R = AB XOR C

PERES

GATE

A

B

C

P = A

Q = A⊕B

R = AB⊕C

**Fig. 4 Block diagram of Peres gate**

**3.2.5 SAYEM GATE:**

Sayem Gate is a 4\*4 reversible gates built using reversible combination of Fredkin gate and Feynman gate.

SAYEM

GATE

A

B

C

D

P = A

Q = B⊕AC

R = B⊕AC⊕D

S = AB⊕C⊕D

**Fig.5 Block diagram of Sayem gate**

**3.2.6 BME GATE:**

BME Gate is a 4\*4 reversible logic gate. The input vector is I(A,B,C,D) and the output vector is O(P,Q,R,S).

BME

GATE

A

B

C

D

P = A

Q = AB⊕C

R = AD⊕C

S = B⊕C⊕D

**Fig. 6 Block diagram of BME gate**

**3.2.7 TSG GATE:**

The TSG gate is a 4\*4 reversible gate. The input vector is I (A, B, C, D) and the output 4. A0403),A0409) , , vector is 0 (P, Q, R, S). The output is defined by P = A, Q = A'C' ^ B', R = (A'C' ^ B') ^ D and S =(A'C' ^ B').D ^ (AB ^ C). The proposed TSG gate is capable of implementing all Boolean functions and can also work singly as a reversible Full adder.

TSG

GATE

A

B

C

D

P = A

Q = ⊕

R =⊕)⊕D

S = (⊕) D ⊕(AB⊕C)

**Fig. 7 Block diagram of TSG Gate**

**COMPARISON BETWEEN IRREVERSIBLE AND REVERSIBLE GATES**

In classical irreversible gates, input states cannot be reconstructed from its outputs states. Therefore, reversible gates are used in which input states can be reconstructed from the output states.

The main difference is reversible gates doesn't lose information whereas irreversible gates do lose information after the computation.