

# Design and Implementation BCD adder Using Integrated Qubit Gates for Quantum Applications

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**Abstract:** Reversible Logic is an emerging technology; it has hellocious applications in various fields. Reversible logic implementation reduces loss of entropy because of bit manipulations. . In this work we present a novel design of reversible 2 DIGIT BCD ADDER using INTEGRATED QUBIT GATES. The reversible BCD adder is designed from 2\*2 control V, Control V+, CNOT, MTSG,FREDKIN[4],FEYMAN, INTEGRATED QUBIT GATES [1].The design of proposed reversible adder- requires minimum quantum cost ,delay by maintaining ancilla inputs and garbage outputs.

**Keywords:** Reversible Logic, Integrated QUBIT GATES, Ancilla, Garbage, Control v,v+

## 1.Introduction

Reversible Logic is an emerging technology; it has hellocious applications in various fields, such as Nano computing, DNA Computing QCA (Quantum Cellular Automata), Optical Computing etc., Limitations of CMOS in Deep sub Micron Regime Leads to failure of Moore's law, leads to development of Reversible circuits. These are more immune to Information loss, this Information loss is in the form of energy dissipated for every bit change. Reversibility concept is an idea from Launder[2] , there is a minimum amount of energy required to change one bit of information, known as the Landauer's limit  $kT \ln 2$  (0.69315).At25 °C, energy loss for one bit change is 0.0178 ev .Bennett [3]showed that loss is negligible if we implement reversible logic. So the primary goal of reversible computing is to minimize energy loss in computing devices and promote speed and density. We present VHDL [9] representation for proposed Design .In section II we represents Basic terminology of reversible logic and basic gates in Reversible logic in Section III we present Creating VHDL Library .In section IV we represent Proposed Work using Prior Work ,In section V conclusion .

## 2.Terminology And Gates

Function: The multiple output Boolean function  $G(x_1; x_2; \dots; x_n)$  of  $n$  Boolean variables is called reversible if: The number of inputs is equal to the number of outputs, any output pattern has an only one input representation.

Basic Gates in reversible logic

The reversible gates used in this work are the NOT gate, the CNOT gate, the Toffoli gate and the Peres gate .Each reversible gate has the quantum cost and the delay associated with it. The NOT gate and the CNOT gate have the quantum cost of 1 and delay of 1  $\Delta$ ; Control V control V + are the basic gates ,by using these gates many gates using reversible logic were designed to meet the requirement ,This

work uses gates like peres ,gate Toffoli gate, Fredkin gate and MTSG gate.

### FEYMAN GATE [4]:

This gate uses one CNOT Gate with quantum cost 1, Details of CNOT gate and Quantum Representation in fig 2

### Control V and Control V+:

The controlled-V gate is shown in Fig. 3 In the controlled-V gate, when the control input 1  $A=0$  then the qubit B will pass through the controlled part unchanged, i.e.,  $Q=B$ . When  $A=1$  then the unitary operation  $V = \frac{(i+1)}{2} \begin{pmatrix} 1 & -i \\ -i & 1 \end{pmatrix}$  is applied to the input B, i.e.,  $Q=V(B)$ .

The controlled-V + gate is shown in Fig4. In the controlled-V + gate when the control input

$A = 0$  then the qubit B will pass through the controlled part unchanged, i.e., we will have  $Q=B$ . When  $A=1$  then the unitary operation  $V + = V - 1$  is applied to the input B, i.e.,  $Q=V +(B)$ .The V and V + quantum gates have the following properties:

### Toffoli Gate [7] [TG]:

Quantum representation of Toffoli gates uses 5 basic gates so its quantum cost is 5.Quantum Representation of Toffoli Gate in Fig 5

### Peres Gate [8] [PG]:

Quantum representation of Peres gates uses 4 basic gates so its quantum cost is 4.Quantum Representation is as shown in Fig 6.By providing a constant input i.e.  $c=0$ ,This Gate acts as Half adder.

### Integrates Qubit Gates:

These are two bit quantum gates allow minimized construction of locally reversible logic structures. [1].

### Fredkin Gate using IQ Gates [1] [4] [FG]:

By using IQ Representation for Fredkin Gate Reduces quantum cost to 5.Quantum Representation of Fredkin gate is in Fig7

**MTSG Gate:**

MTSG Gate is modified TG [13] Gate, It is 4\*4 GATE so by proving a constant input to i.e. D=0, the above gate acts as Full Adder in classical logic. Quantum Representation of MTSG gate in fig 8 MTSG gate is obtained by cascading two peres GATES

**3. Creation of Qubit Library [1]:**

For the effective representation of reversible logic structures using reversible logic using integrated qubit gates is achieved by creation of library called "QUBIT". By using VHDL-93[6]

$$\begin{aligned} V \times V &= \text{NOT} \\ V \times V^+ &= V^+ \times V = I \\ V^+ \times V^+ &= \text{NOT} \end{aligned}$$

**Steps in Creating Qubit Library:**

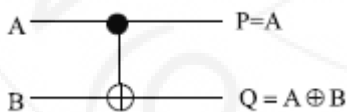
Basic Unit in Quantum Computation is QUBIT ,Spins of Qubit is represented in Bloch Sphere[5] Has Multiple states includes 0,1,v,V,p,P,U.Where p,P,V,v are outputs from Control V+, control V gate.

**Table 1: Integrated Qubit Gates Spin Operation LOOK UP TABLE.**

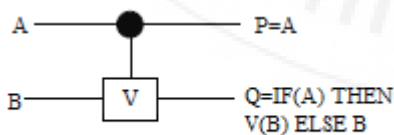
Qubit	Description
0	Logic '0'
1	Logic '1'
v	V transformation with '0' input
V	V transformation with '1' input
p	V+ transformation with '0' input
P	V +transformation with '1' input
U	Qubit is in an Unknown State



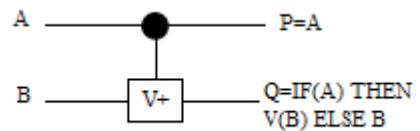
**Figure 1: Quantum Representation of QNOT.**



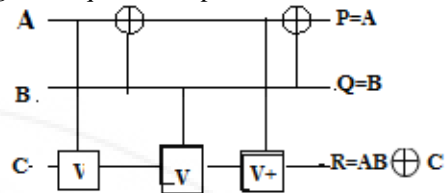
**Figure 2: Quantum Representation of Feynman Gate**



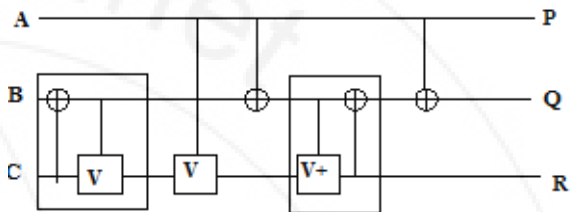
**Figure 3: Quantum Representation of Control v**



**Figure 4: quantum representation of control V+**

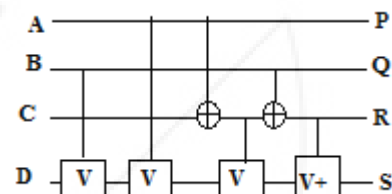


**Figure 5: Quantum representation of Toffoli Gate**



$$P=A, Q=\bar{A}B \oplus AC, R=\bar{A}C \oplus AB$$

**Figure 6: Quantum representation of Fredkin Gate using IQ Gates**



$$P=A, Q=A \oplus B, R=A \oplus B \oplus C, S=(A \oplus B) C \oplus AB \oplus D$$

**Figure 7: Quantum Representation of MTSG Gate**

**Binary Addition:**

BCD numbers are represented in 4 bit format, Inputs to the binary adder are in range of 0-9, 4bit binary addition in reversible phenomenon can be done by using reversible parallel adder using 4 MTSG gates .By providing 1 constant input and 2 garbage outputs to MTSG gives full one full adder .

**Overflow Detector:**

In maximum range is 1111 for a 4 bit ranged Binary Numbers i.e. 15 , so the numbers from 10 to 15 are not valid BDC numbers and they can detected by using expression,OF = (X1 + x2)X3 XOR a4 where x1,x2,x3 outputs of parallel adder .and a4 is its carry ..If OF = '1' indicates that numbers are not in range of BCD ,So number '6' is added to sum from TG gate is used to get overflow output by FG gate Another FG is used to restore modified outputs Overflow Removal Circuit: This uses Peres, Fredkin, MTSG gates for processing it takes control input from detection circuit

**BCD ADDER:**

The design of reversible BCD adder, the primary concern is to keep the number gates and number of garbage outputs as minimum as possible. As the number of gates is reduced, therefore delay will also be reduced. Garbage output is

another important criterion. Circuits with less number of garbage outputs are always desirable. Several lower bounds for reversible BCD adder in terms of number of gates and garbage outputs are presented in this section.

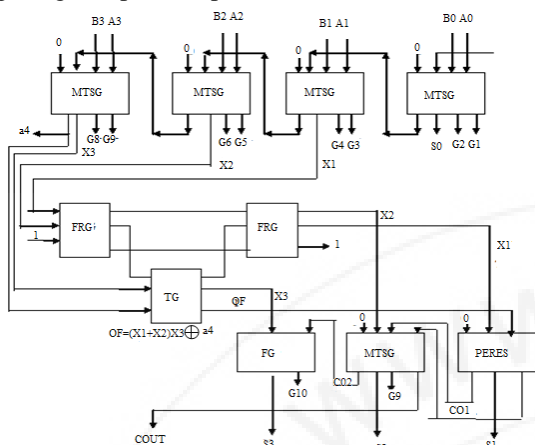


Figure 8: DIGIT BCD ADDER

### 4. Proposed 2 Digit BCD Adder

By using two BCD adders we can design two digits BCD added. We have to take two 8 bits as input and by giving 4 LSB of two inputs to 1 digit BCD Adder, this circuit produce BCD SUM, carry, by giving carry to i/p of next 1 digit bcd adder along with 1st four MSB to this we will get resultant BCD SUM., By combining outputs of 2, 1 bit BDC adders we will get 2 digit BCD adder Output.

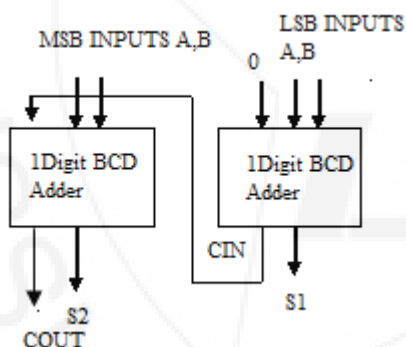


Figure 9: 2 DIGIT BCD ADDER

Simulation Results of Logic Structures:

4h1	4hA	4hB	4hC	4hD	4hE	4hF
4hB	4h0					
4hC	4hA	4hB	4hC	4hD	4hE	4hF
1	1		1			
4h2	4h0	4h1	4h2	4h3	4h4	4h5

Figure 10: DIGIT BCD ADDERS

36	53	18	36
37	35	24	37
73	88	42	73
0	0	1	0

Figure 11: 2Digit BCD ADDER

### 5. Conclusion

In this Paper we propose 2 Digit BCD Adder using Integrated Qubit Gates is designed. This circuit has less quantum cost than classical logic and reversible gates. The Functionality of above circuit is verified by using Modelsim 10.1 We can design m bit compact, fast adders for quantum applications in future.

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