OPEN ACCESS
International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8 Issue-4, November 2019

Design of Coplanar Circuit Switching Network in Quantum Dot Cellular Automata

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Abstract*: Quantum dot Cellular Automata (QCA) is the alternative technology to the classic CMOS technology since it is going to attain a road block in reducing power consumption and increase speed of the digital circuits. Circuit switching network is the basic component in order to transmit input signal among the different users within the communication network. A novel crossbar switch is proposed in this paper to design this communication network. The basic building blocks of the proposed circuit Switching network are Crossbar switch, Multiplexer and Demultiplexer. Multilayer QCA cells are almost impossible when compared to the fabrication feasibility of the single layer design. So this design is achieved in single layer.Circuit switching network is designed and compared with existing one using QCA Designer2.0.3.The designs are verified through matching up with truth tables.

***Keywords* : QCA, Crossbar switch,Circuit Switching network,**

I. INTRODUCTION

Quantum – dot cellular automata is one of the most promising solution in reducing area , power consumption and in increasing speed of the digital circuits.Binary values '0' and '1' can be represented with the help of the position of electrons.Basic logic gatesin the QCA are majority gate and Inverter[7-9].Some of the advantages of QCA technology over CMOS technology are:

1. CMOS transistors cannot be scaled beyond a particular size any further
2. CMOS interconnects have not grown to Work as fast as the device them
3. Power consumption due to leakage current is significant in the CMOS technology and has no cent percent solution till date[10-14].

Optimistic assumptions indicate that the technology has the potential to break the terahertz barrier.It has low power consumption.Electrons are the main elements in QCA to perform operations and to propagate informations.Dr.Craig Lent at Notre Dame titled Quantum-dot cellular automata, which is a new form of logic gates using quantum dots.The logic unit in QCA is the QCA cell.It is composed of four quantum dots[15-17].

Circuit switching network is the basic component inorder to transmit input signal among the different users within the communication network.The main building blocks of the proposed circuit switching network are crossbarswitch, multiplexer and demultiplexer.Multilayer QCA cells is almost impossible when compared to the fabrication feasibility of the single layer design.So this design is achieved in single layer.The implementation and simulation of the proposed circuit switched network is achieved through QCA designer 2.0.3 tool .The designs are verified through matching up with truth tables.

II. RELATED WORKS

There are only few works reported to look into the application of QCA in designing the architecture of nanocommunication.In [1] Circuit switching network is achieved in a single layer and it is evaluated in terms of area,latency and logic gates.It uses 382 cells and of area 1.02 μm^2.In [2],a novel structure for the 2x1,4x1,8x1 multiplexer are designed and it does not follow any Boolean function.The proposed structures performance is high interms of area, latency and power consumption.In [3],a new and efficient architecture for 2x1,4x1,8x1 multiplexer are implemented with the coplanar crossover.In [4],a reversible 2x2 crossbar switch is designed and its impact on information processing is analysed.Parameters likedensity, logic gates and latency are considered in order to confirm faster operating speed and high device density.In [5],a novel design of 2x1multiplexer is proposed to reduce delay and area.

III. QCA BASED CROSSBAR SWITCH

Crossbar switch can be achieved using 2x1 multiplexer.It is a logic circuit that performs switching operation by connecting multiple input to multiple output line.It has multiple input and multiple output line that is represented as mxn crossbar switch.It forms the crossed like pattern because of the interconnection between input and output lines. The simultaneous connections do not affect the communication between other input and output lines.The simple example is 2x2 crossbar switch as shown in Fig.1.It has two input lines A,B and two output lines C,D.S is the control signal (i.e.,switch).

Manuscript published on November 30, 2019.
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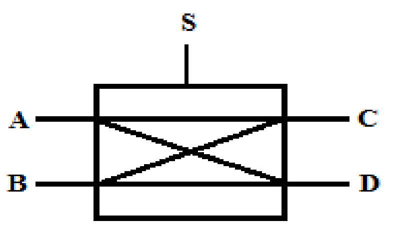

Fig. 1. Crossbar switch 2x2

In this 2x2 crossbar switch,if the control signal is zero (S=0),A is connected with C and B is connected with D.Similarly,if the control signal is one (S=1),A is connected with D and B is connected with C.It is explored in truth table as shown in Table1. 2x2 crossbar switch circuit diagram is shown in Fig.2 It is described through equations as follows,

If S=0,

A=C (1)

B=D (2)

If S=1,

A=D (3)

B=C (4)

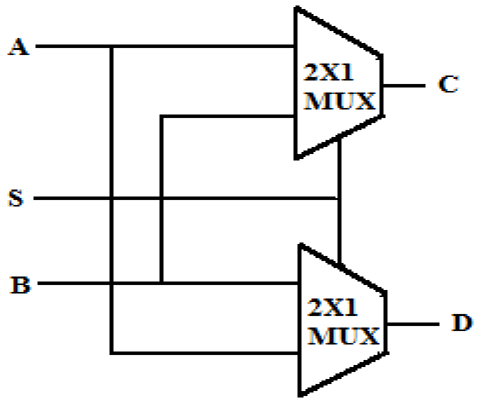

Fig.2 Crossbar switch 2x2(Circuit diagram)

The first 2x1 MUX generates output expression for C and second 2x1 MUX generates output expression for D .Schematic diagram for 2x2 crossbar switch is shown in Fig.3.

Table 1 Truth table of 2x2 crossbar switch

Input			Output	
Control input (S)	A	B	C	D
0	0	0	0	0
0	0	1	0	1
0	1	0	1	0
0	1	1	1	1
1	0	0	0	0
1	0	1	1	0
1	1	0	0	1
1	1	1	1	1

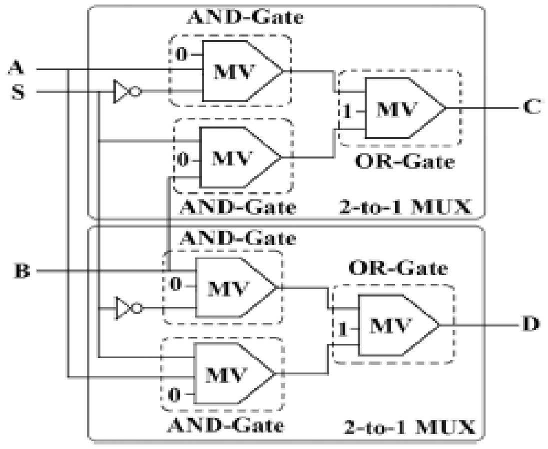

Fig.3 2x2 Crossbar switch(Schematic diagram)

The design is made up of 6 Majority gates(MVs) and 2 inverters.The logic expression for 2x2 crossbar switch is given as

C=AS'+BS (5)

D=AS+BS' (6)

IV. CIRCUIT SWITCHING NETWORK

Circuit switching is a method of implementing a communication network in order to establish a connection between two nodes before they may communicate. It is shown in Fig.4 An example for circuit switching network is the conventional telephone network. When a call is made by any user ,it creates a connection between two telephones with the help of switches in telephone exchanges for as long as the call lasts.

Circuit switching network is made up of a set of switches and it is connected by physical links. In which each link is divided into n channels. The advantages of circuit switching network is that it provides the continuous transfer of data by using same path with the maximal utilization of available bandwidth for that communication.One disadvantage is that it is inefficient because the unused capacity to a dedicated connection cannot be used by a other connections on the same network.

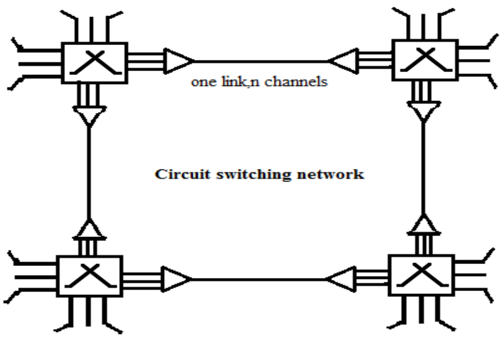

Fig. 4 Circuit switching network

V. EXISTING SYSTEM

A multiplexer is a device which allows one or more signals to be selected, combined and transmit on a single shared medium at a high speed. It is a multiple input and single output switch. With two input signal and one output signal, it is referred to as 2x1 Multiplexer.

Retrieval Number: D4227118419/2019©BEIESP
DOI:10.35940/ijrte.D4227.118419
Journal Website: www.ijrte.org

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In existing system, crossbar switch is composed of 2x1 MUX which uses 22 cells and of area 0.03µm^2.QCA layout of existing 2x1 MUX is shown in Fig.5

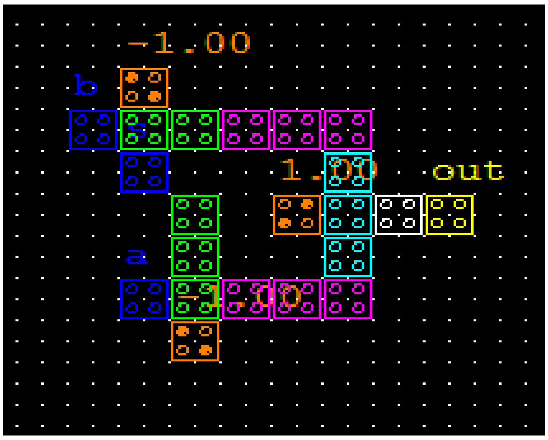

Fig.5 Existing 2x1 Multiplexer

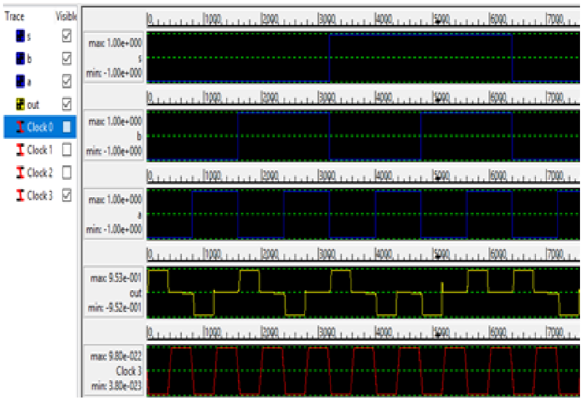

Fig. 6 Simulation result of existing 2x1 Multiplexer

If switch is zero (i.e.,S=0), input will be appeared in out.If switch is one (i.e.,S=1),input b will be appeared in out.The simulated result of existing 2x1 Multiplexer is shown in Fig.6. Different colours are used to represent input cells,output cells and clocking zones.The green, purple, turquoise, purple,turquoise, white, blue, yellow, orange represents Clock 0, Clock 1, Clock 2, Clock 3,input cells,output cells and fixed polarisation. It has 3 Majority gates(MVs)If a cell is fixed as -1 in majority gate,it act as AND gate .If a cell is fixed as 1 in majority gate ,it act as OR gate.The existing 2x1 Multiplexer is composed of two AND gate and 1 OR gate.

Existing crossbar switch is composed of two 2x1 Multiplexer.The design uses 126 cells and of area 0.14 µm^2.The operation of 2x2 crossbar switch is explored in Table 1.QCA layout of existing crossbar switch is shown in Fig.7. The simulated result of existing crossbar switch is shown in Fig.8.

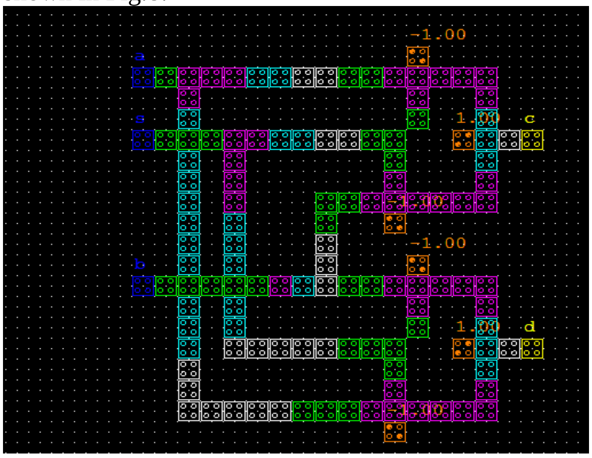

Fig.7 Existing 2x2 Crossbar switch

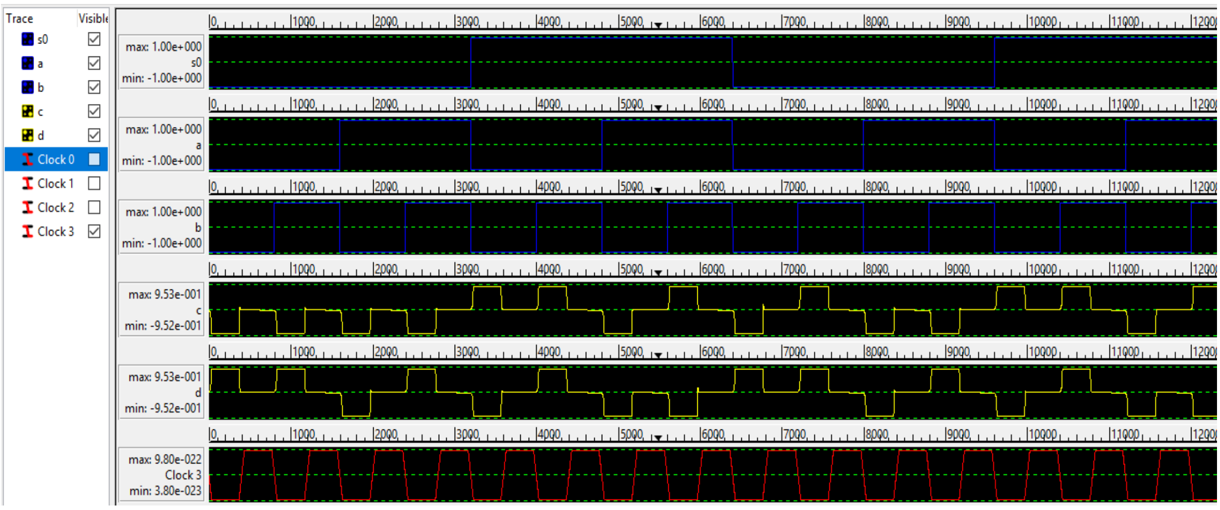

Fig.8 Simulation result of existing 2x2 crossbar switch

Existing transmitter block is composed of one 2x2 crossbar switch and one 2x1 multiplexer. It uses 178 cells and of area 0.24 µm^2.QCA layout of existing transmitter block is shown in Fig.9 Its simulation result is shown in Fig.10. 'a' and 'b'are the inputs to the transmitter, 'out' is the corresponding transmitter output.s1 and s2 are the control inputs.

If s1 = 0 and s2 = 0, the input given to 'a' will appear at output line 'out', i.e., out=A. If s1= 0 and s2= 1, the input given to 'b' will appear at output line out, i.e., out=b. Similarly, by considering the different values of control bits s1 and s2 the truth table for transmitter block is formed and shown in Table II. Thus, the logic expression for output bit, out can be drawn as

Out=(S2)'[a(s1)'+b(s1)]+[b(s1)'+a(s1)] (7)

Table II: Truth table of transmitter block

Input		Output
Control bit (s1)	**Control bit (s2)**	**Output (out)**
0	0	a
0	1	b
1	0	b
1	1	a

Existing receiver block is composed of one 2x2 crossbar switch and one 1x2 demultiplexer.It uses 166 cells and of area 0.21 μm^2.QCA layout of existing receiver block is shown in Fig.11 Its simulation result is shown in Fig.12.'I' is the input to the receiver and 'c' and'd' are the corresponding output to the receiver block.'s0' and 's' are the control signals.

In these receiver block, if s0= 0 and s = 0, the input given to 'I' will appear at output line 'c', i.e., c=I. If s0 = 0 and s = 1, the input given to 'I' will appear at output line'd', i.e., d=I. The truth table for receiver block is formed and shown in Table III. Thus, the logic expression for output bits, c and d can be drawn as

$$c=(Is)'(s0)'+(Is)(s0) \quad (8)$$

$$d=(Is)(s0)'+(Is)'(s0) \quad (9)$$

Table III: Truth table of receiver block

Input		Output	
Co ntrol bit (s)	**Co ntrol bit (s0)**	**c**	**d**
0	0	I	0
0	1	0	I
1	0	0	I
1	1	I	0

Existing circuit switching network is composed of transmitter block and receiver block which uses 382 cells and of area 1.02 μm^2.QCA layout of existing circuit switching network is shown in Fig.13.Its simulation output is shown in Fig.14.

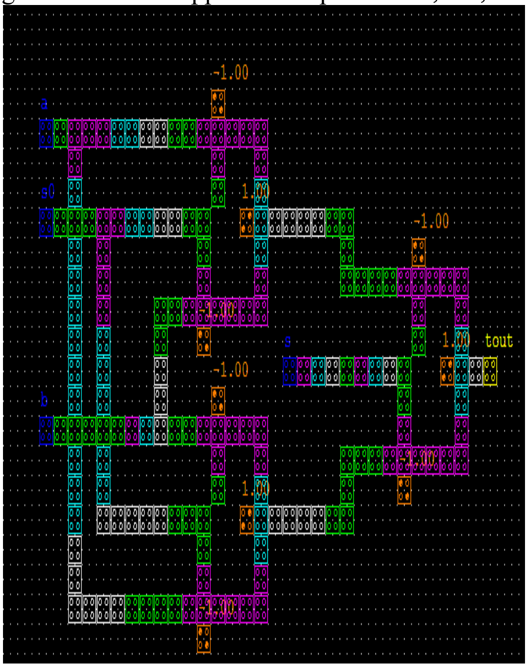

Fig 9. Existing Transmitter block

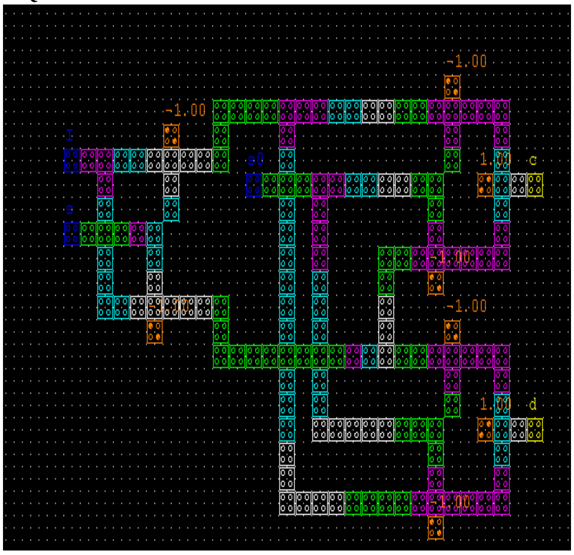

Fig.11 Existing receiver block

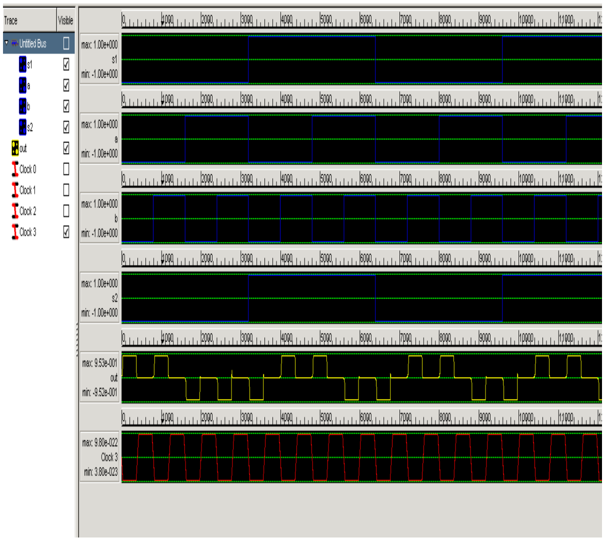

Fig.10 Simulated result of existing transmitter block

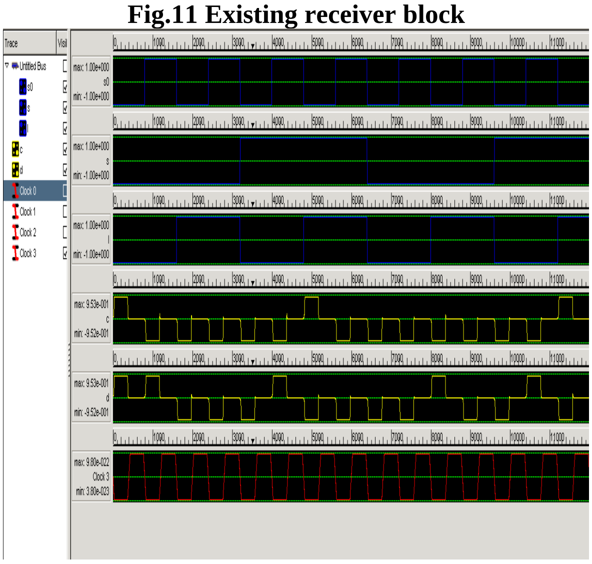

Fig. 12 Simulated result of existing receiver block

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DOI:10.35940/ijrte.D4227.118419
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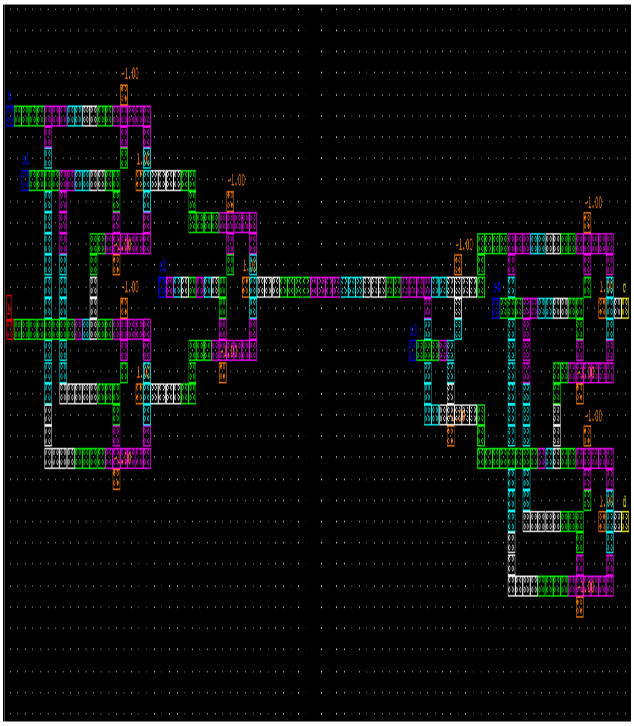

Fig.13 Existing Circuit switching network

VI. PROPOSED SYSTEM

In proposed system, a crossbar switch is composed of 2x1 MUX which uses 19 cells and area of 0.02μm^2.The difference between the layout of multiplexer in the proposed when compared to existing is that fixed polarization of the AND gates are common.QCA Layout of proposed 2x1 multiplexer is shown in Fig.15.

The simulation result of proposed 2x1 multiplexer is same as the existing 2x1 multiplexer and the result is shown in Fig.16.

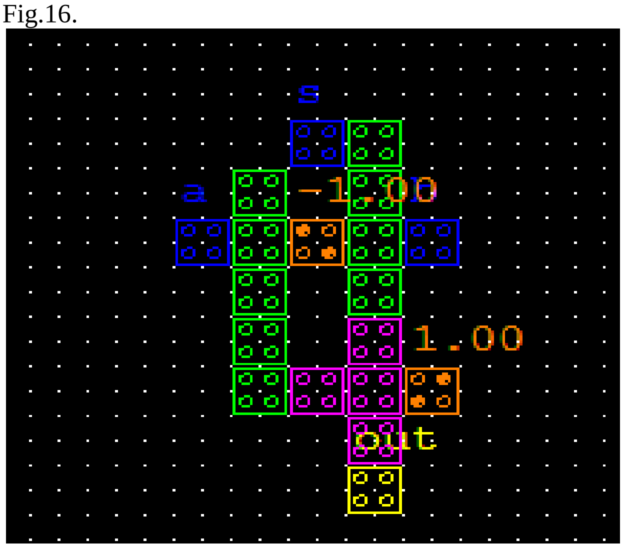

Fig.15 Proposed 2x1 Multiplexer

Proposed crossbar switch is composed of two 2x1 multiplexer.The design uses 81 cells and area of 0.08μm^2. QCA layout of proposed crossbar switch is shown in Fig.17. The simulated result of proposed crossbar switch is shown in Fig.18

Proposed transmitter block is composed of one 2x2 crossbar switch and one 2x1 multiplexer.It uses 126 cells and of area 0.16μm^2.QCA layout of proposed transmitter block is shown in Fig.19 and its simulation result is shown in Fig.20.Proposed receiver block is composed of one 2x2 crossbar switch and one 1x2 demultiplexer.It uses 136 cells and of area 0.16 μm^2.QCA layout of proposed receiver block is shown in Fig.21 and its simulation result is shown in Fig.22

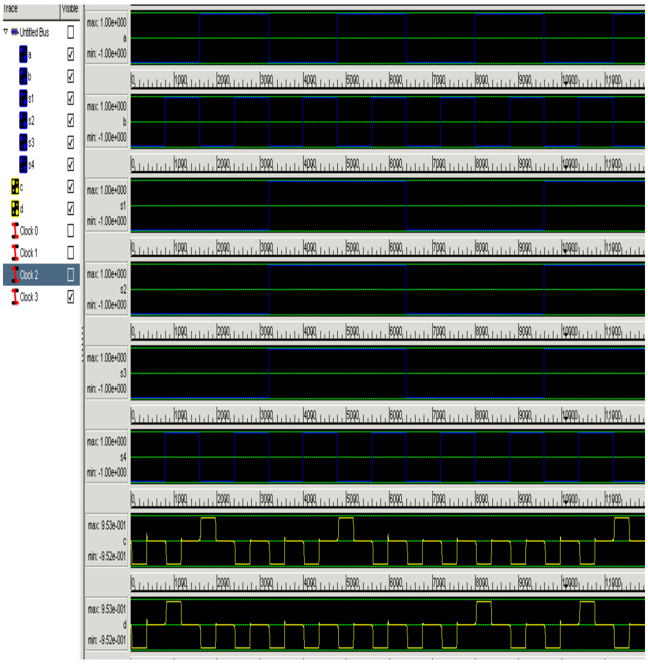

Fig.14 Simulated result of circuit switching network

Proposed circuit switching network is composed of transmitter block and receiver block which uses 269 cells and of area 0.43 μm^2.QCA layout of proposed circuit switching network is shown in Fig.23 and its simulation output is shown in Fig.24.

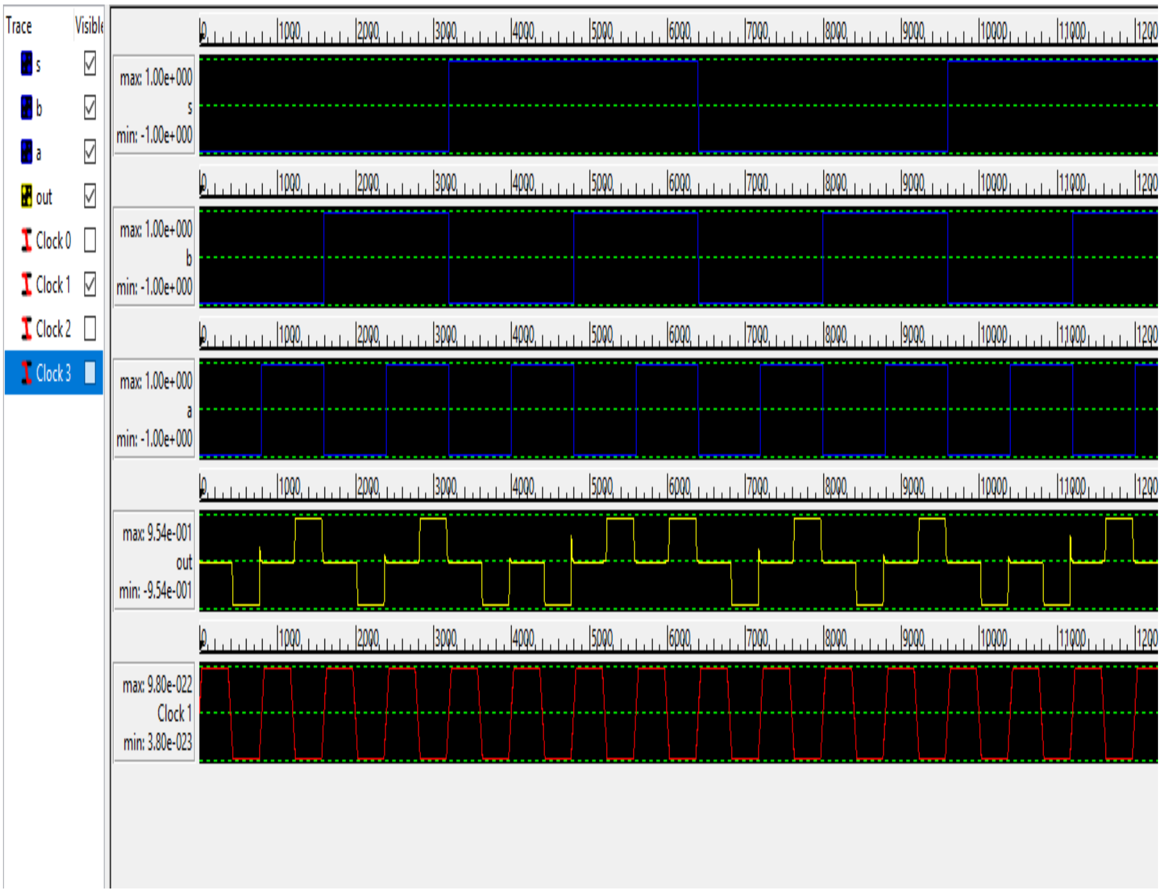

Fig.16 Simulation result for proposed 2x1 Multiplexer

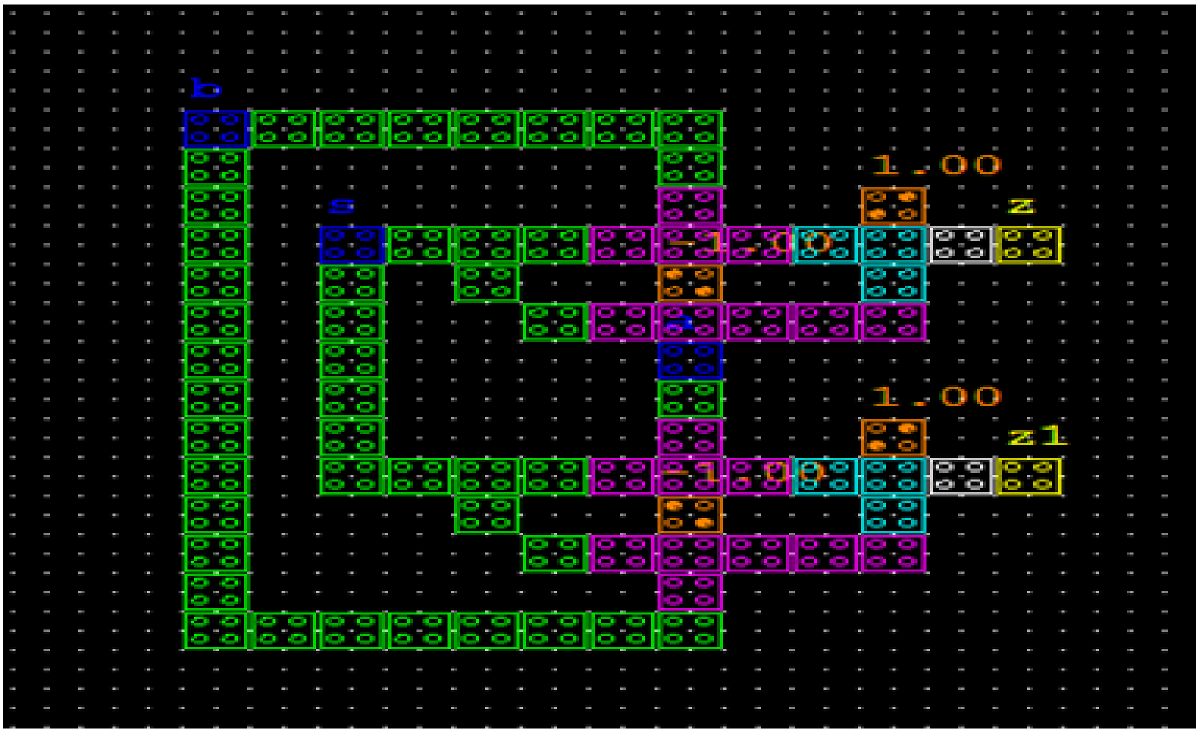

Fig.17 QCA layout for Proposed crossbar switch

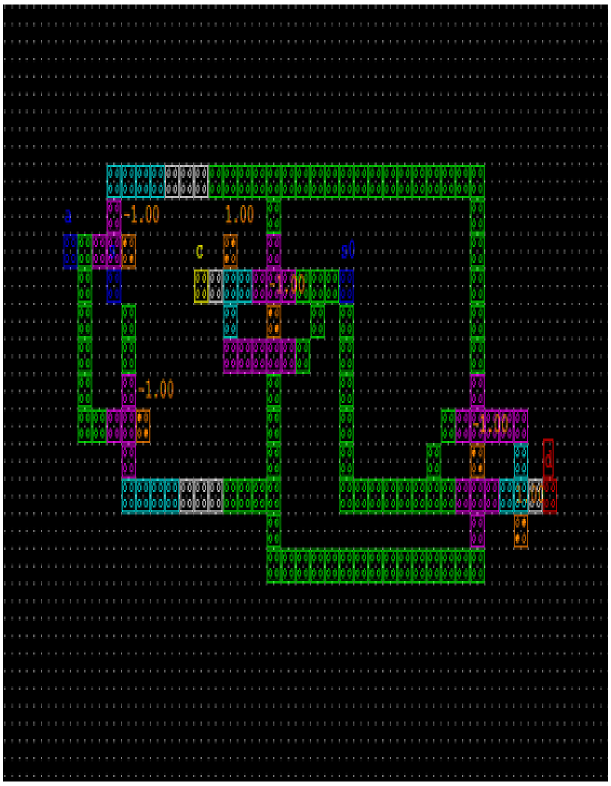

Fig. 21 QCA Layout for proposed receiver block

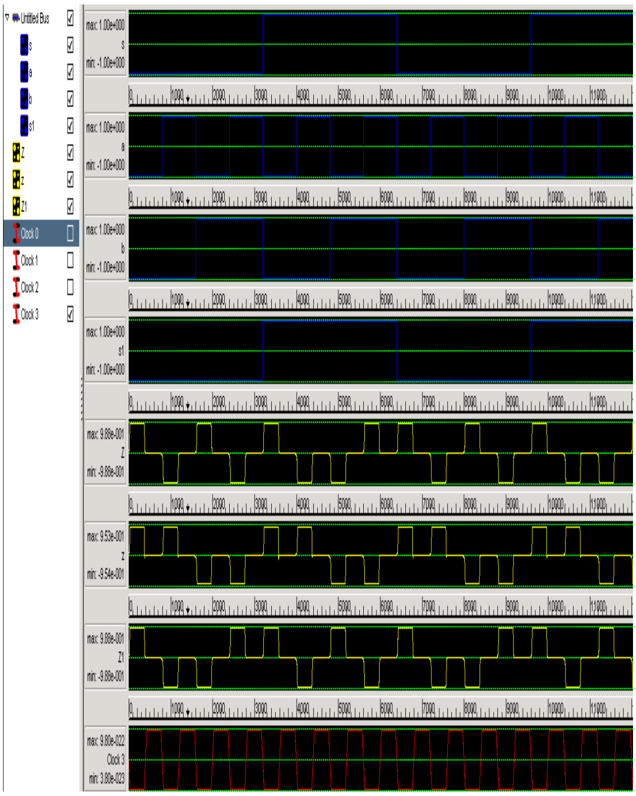

Fig.19. QCA Layout for proposed transmitter block

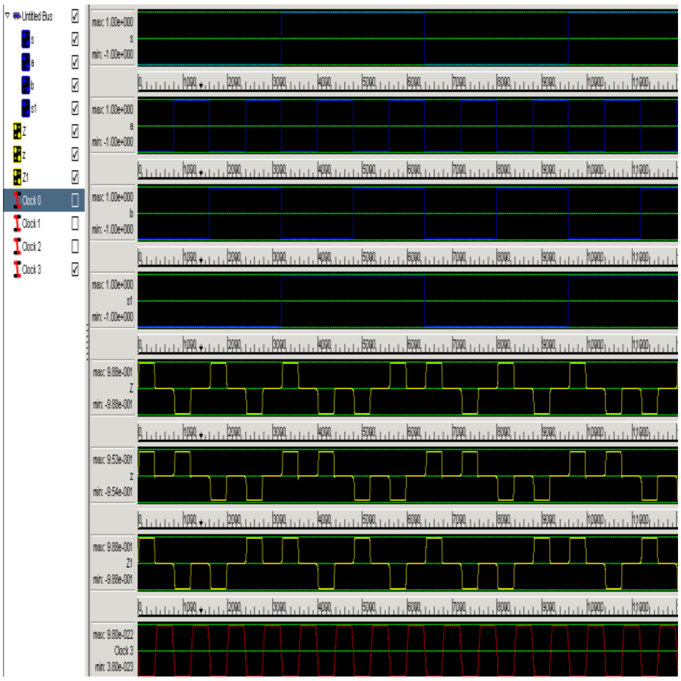

Fig.20 Simulation Output for proposed transmitter block

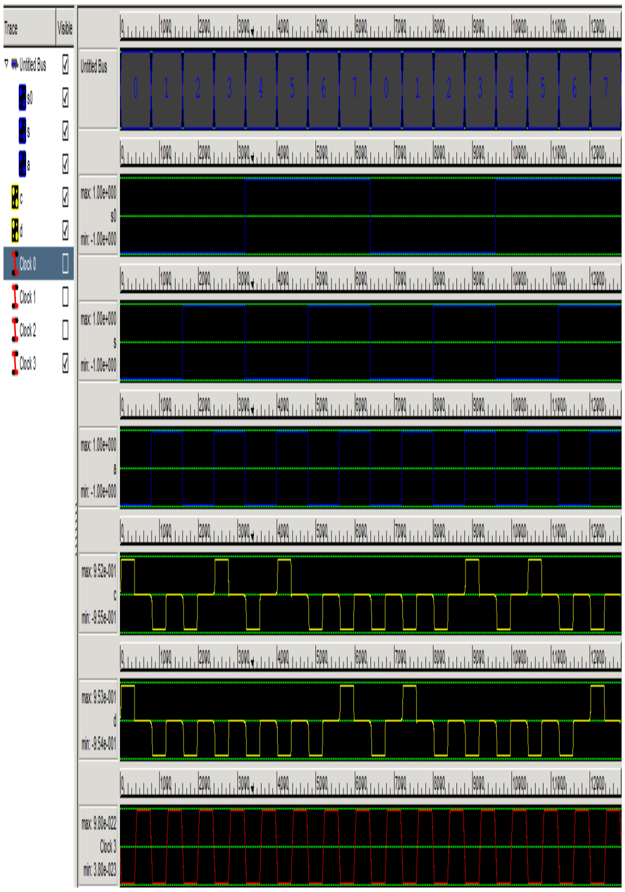

Fig.22 Simulation result for proposed receiver block

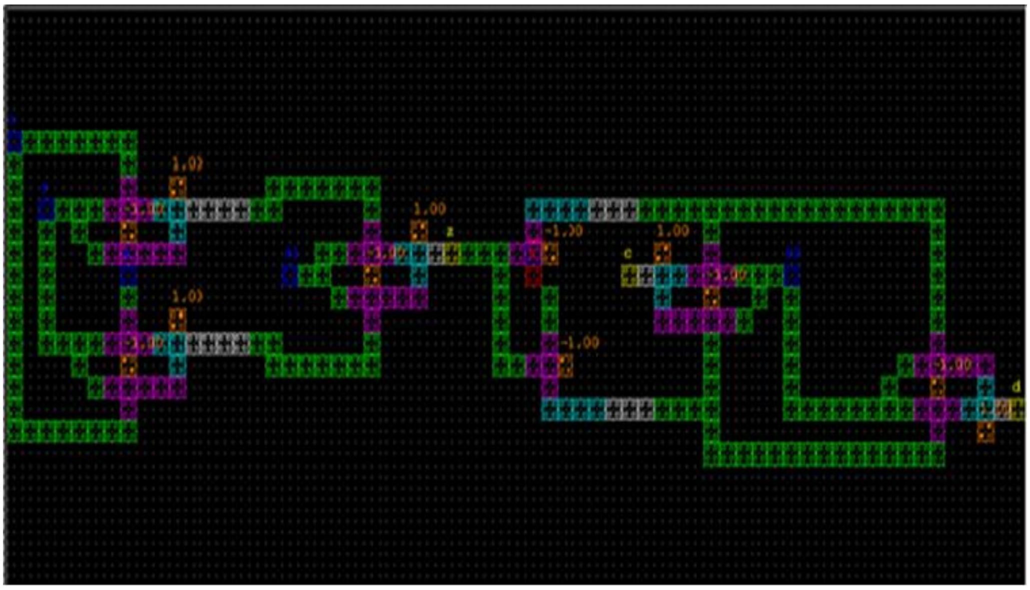

Fig.23 QCA Layout for proposed Circuit switched network

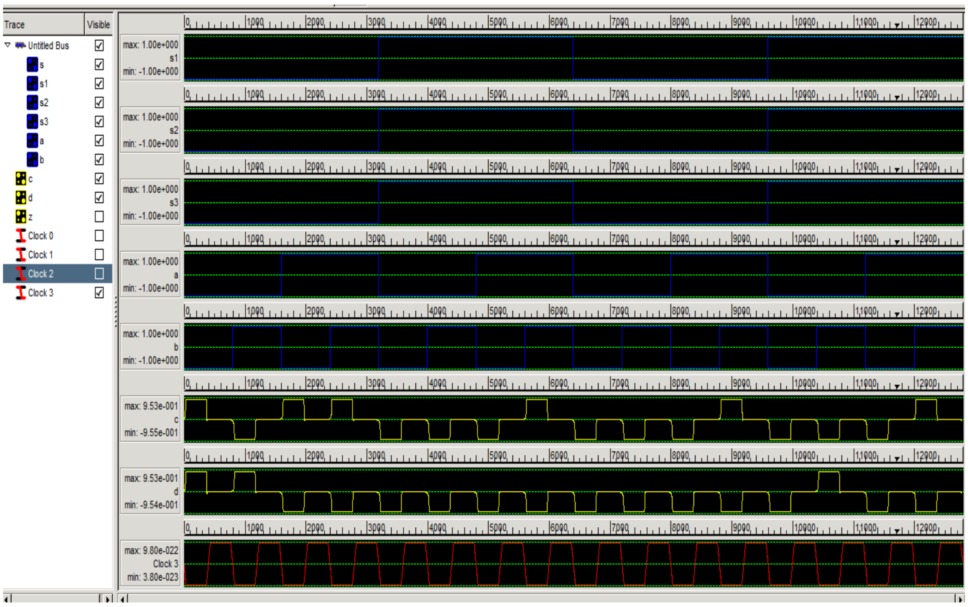

Fig.24 Simulation result for circuit switched network

Table IV: COMPARISON OF CELL COUNT

Design	Existing design	Proposed design
Crossbar switch	126	81
Transmitter	178	126
Receiver	166	136
Circuit switched network	382	269

Table V: COMPARISON OF AREA

Design	Existing design (μm^2)	Proposed design (μm^2)
Crossbar switch	0.14	0.08
Transmitter	0.24	0.16
Receiver	0.21	0.16
Circuit switched network	1.02	0.43

The table IV shows the comparison cell count result for Existing design and proposed design whereas table V shows the comparison of area for existing design and proposed design.

VII. CONCLUSION AND FUTURE SCOPE

In this paper, single layer circuit switched network in QCA technology is simulated. The design of circuit switched network is achieved using a crossbar switch, multiplexer and demultiplexer.Cell count and area are reduced when compared to the existing circuit switched network. In this paper, area and cell count of the proposed circuit switching network are reduced by 57.84% and 29.58% respectively when compared to existing circuit switching network.

In future, Circuit Switching Network can be implemented with multiple users using mxn crossbar switch.

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