Experiment No. : 04

Aim : To implement 4 - bit Arithmetic Logic Unit.

Objective: To understand behavior of arithmetic logic unit from working module and designing an arithmetic logic unit for given parameter.

Theory :

Design of ALU:

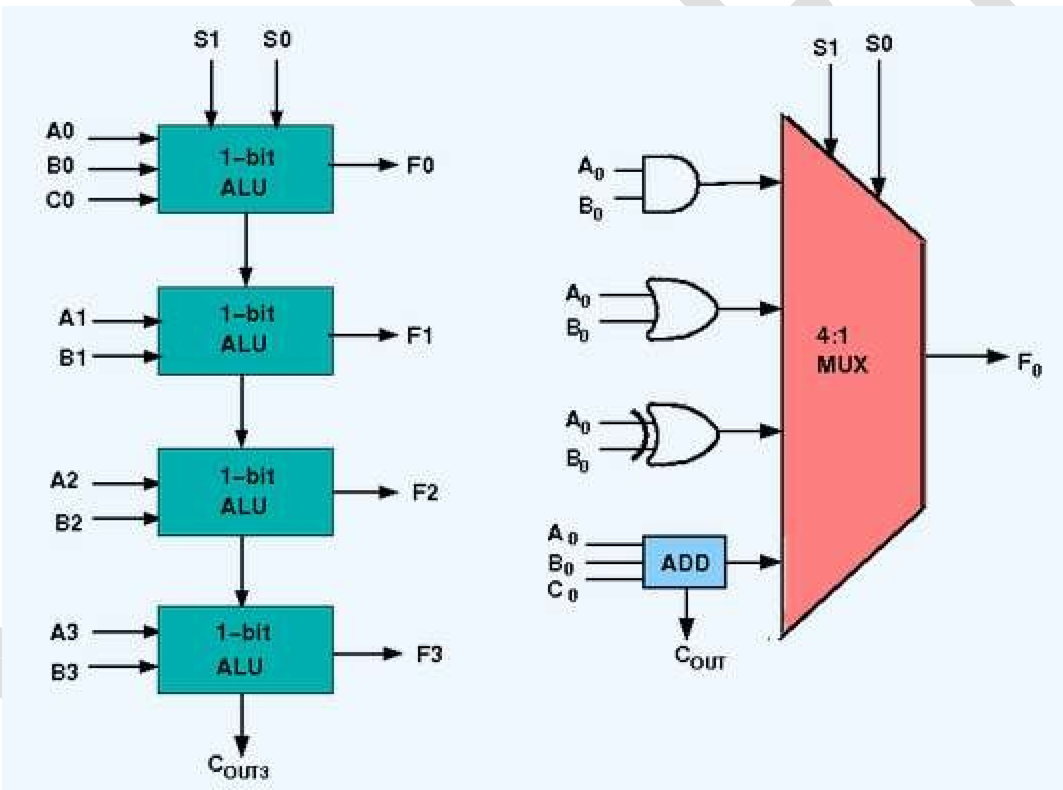


Fig 1: 4-bit ALU block is combined using 4 1-bit ALU block

Design Issues :

The circuit functionality of a 1 bit ALU is shown here, depending upon the control signal S_1 and S_0 the circuit operates as follows:

for Control signal $\mathbf{S_1 = 0}$, $S_0 = 0$, the output is **A And B**,

for Control signal $\mathbf{S_1 = 0}$, $S_0 = 1$, the output is **A Or B**,

for Control signal $\mathbf{S_1 = 1}$, $S_0 = 0$, the output is **A Xor B**,

for Control signal $\mathbf{S_1 = 1}$, $S_0 = 1$, the output is **A Add B**.

The truth table for 16-bit ALU with capabilities similar to 74181 is shown here:

Required functionality of ALU (inputs and outputs are active high)

Mode Select				F_n for active HIGH operands	
Inputs				Logic	Arithmetic (note 2)
S3	S2	S1	S0	(M = H)	(M = L) (C_n=L)
L	L	L	L	A'	A
L	L	L	H	A'+B'	A+B
L	L	H	L	A'B	A+B'
L	L	H	H	Logic 0	minus 1
L	H	L	L	(AB)'	A plus AB'
L	H	L	H	B'	(A + B) plus AB'
L	H	H	L	A ⊕ B	A minus B minus 1
L	H	H	H	AB'	AB minus 1
H	L	L	L	A'+B	A plus AB
H	L	L	H	(A ⊕ B)'	A plus B
H	L	H	L	B	(A + B') plus AB
H	L	H	H	AB	AB minus 1
H	H	L	L	Logic 1	A plus A (Note 1)
H	H	L	H	A+B'	(A + B) plus A
H	H	H	L	A+B	(A + B') plus A
H	H	H	H	A	A minus 1

The L denotes the logic low and H denotes logic high.

Fig 2: Truth Table of 4-bit ALU

Procedure:

1. Start the simulator as directed. This simulator supports 5-valued logic.
2. To design the circuit we need 4 1-bit ALU, 11 Bit switch(to give input, which will toggle its value with a double click), 5 Bit displays(for seeing output), wires.
3. The pin configuration of a component is shown whenever the mouse is hovered on any canned component of the palette. Pin numbering starts from 1 and from the bottom left corner(indicating with the circle) and increases anticlockwise.
4. For 1-bit ALU input A0 is in pin-9,B0 is in pin-10, C0 is in pin-11(this is input carry), for selection of operation, S0 is in pin-12, S1 is in pin-13, output F is in pin-8 and output carry is pin-7
5. Click on the 1-bit ALU component(in the Other Component drawer in the pallet) and then click on the position of the editor window where you want to add the component(no drag

and drop, simple click will serve the purpose), likewise add 3 more 1-bit ALU(from the other Component drawer in the pallet), 11 Bit switches and 5 Bit Displays(from Display and Input drawer of the pallet, if it is not seen scroll down in the drawer), 3 digital display and 1 bit Displays(from Display and Input drawer of the pallet,if it is not seen scroll down in the drawer)

6. To connect any two components select the Connection menu of Palette, and then click on the Source terminal and click on the target terminal. According to the circuit diagram connect all the components. Connect the Bit switches with the inputs and Bit displays component with the outputs. After the connection is over click the selection tool in the pallete.
7. See the output, in the screenshot diagram we have given the value of S1 S0=11 which will perform add operation and two number input as A0 A1 A2 A3=0010 and B0 B1 B2 B3=0100 so get output F0 F1 F2 F3=0110 as sum and 0 as carry which is indeed an add operation. you can also use many other combination of different values and check the result. The operations are implemented using the truth table for 4 bit ALU given in the theory.

Circuit diagram of 4 bit ALU:

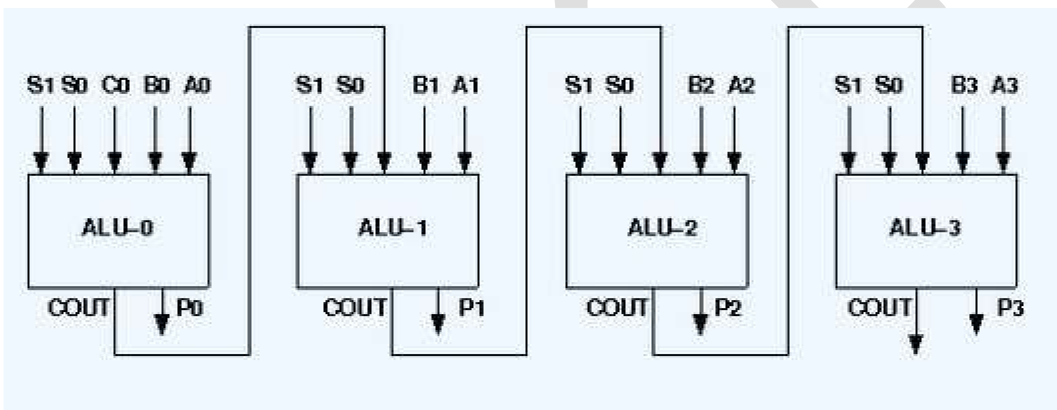


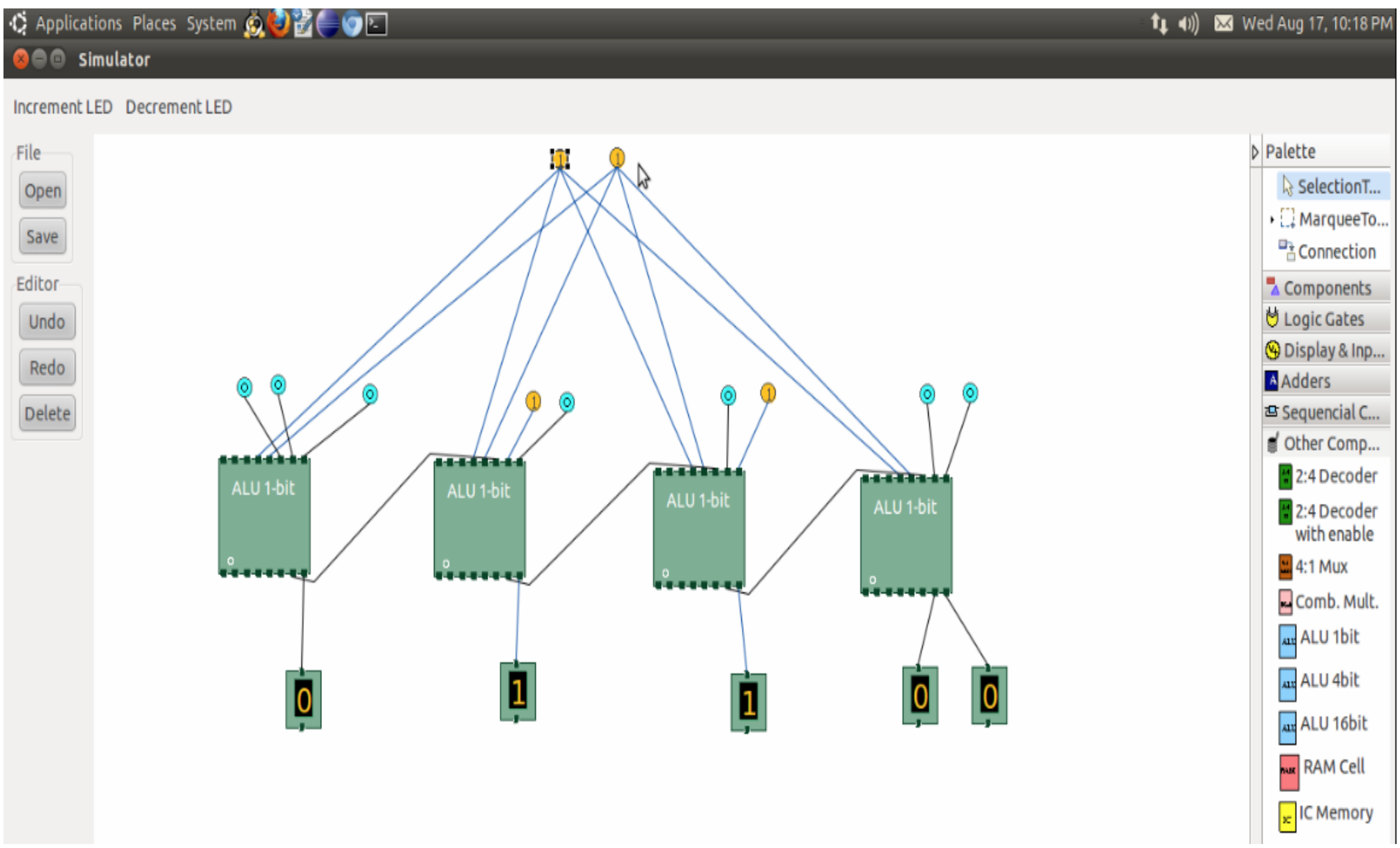
Fig 3: Circuit diagram of 4-bit ALU

Components :

To build any 4 bit ALU, we need :

1. AND gate, OR gate, XOR gate
2. Full Adder,
3. 4-to-1 MUX<
4. Wires to connect.

Screenshot of Design of 4 bit ALU:



Industrial Application: ALU is designed to perform complex functions in a system, the resulting higher circuit complexity, cost, power consumption and larger size makes this impractical in many cases. ALU is a group of simple ALUs that calculates a square root in stages, with intermediate results passing through ALUs arranged like a factory production line.

Conclusion: Hence we have implemented, simulated, analyzed 4 bit ALU