Experiment No.10
Implement ALU design.
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Date of Performance:
Date of Submission:

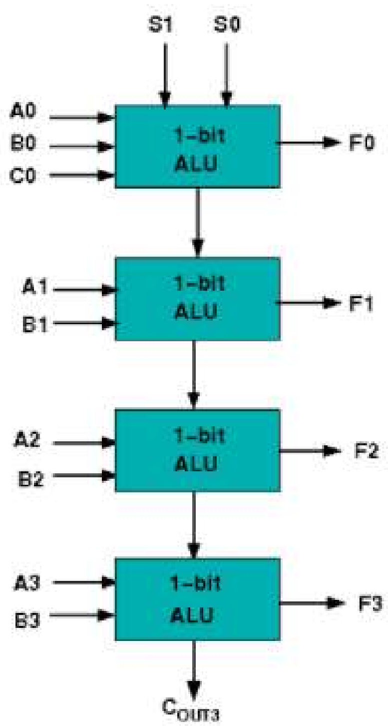
Aim: To implement ALU design

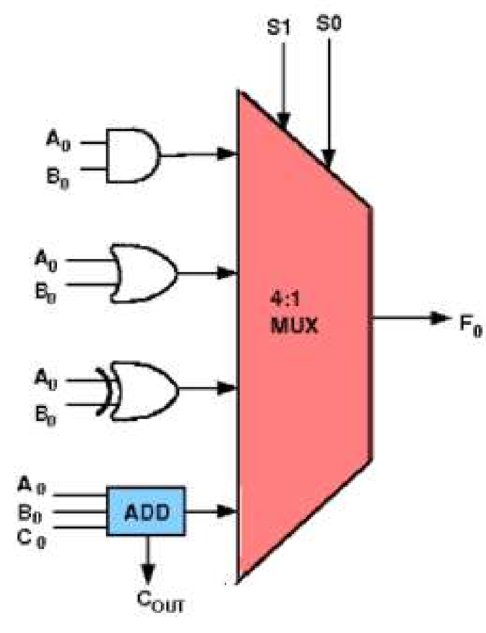
Objective : Objective of 4 bit arithmetic logic unit (with AND, OR, XOR, ADD operation):

1. To understand behaviour of the arithmetic logic unit from the working module.
2. To Design an arithmetic logic unit for given parameters.

Theory:

ALU or Arithmetic Logical Unit is a digital circuit to do arithmetic operations like addition, subtraction,division, multiplication and logical operations like and, or, xor, nand, nor etc. A simple block diagram of a 4 bit ALU for operations and,or,xor and Add is shown here :





The 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 S1 and S0 the circuit operates as follows:

for Control signal S1 = 0 , S0 = 0, the output is A And B,
for Control signal S1 = 0 , S0 = 1, the output is A Or B,
for Control signal S1 = 1 , S0 = 0, the output is A Xor B,
for Control signal S1 = 1 , S0 = 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)

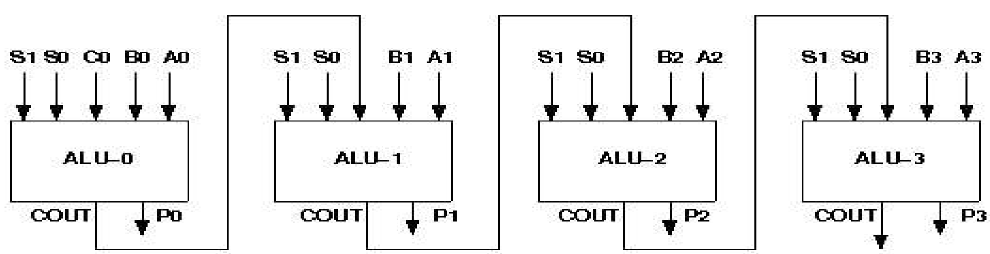
MODE SELECT				F_N FOR ACTIVE HIGH OPERANDS	
INPUTS				LOGIC	ARITHMETIC (NOTE 2)
S3	S2	S1	S0	(M = H)	(M = L) (Cn=L)
L	L	L	L	A'	A
L	L	L	H	A'+B'	A+B
L	L	H	L	A'B	A+B'
L	L	H	H	Logic 0	minus 1
L	H	L	L	(AB)'	A plus AB'
L	H	L	H	B'	(A + B) plus AB'
L	H	H	L	A ⊕ B	A minus B minus 1
L	H	H	H	AB'	AB minus 1
H	L	L	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

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 components 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:

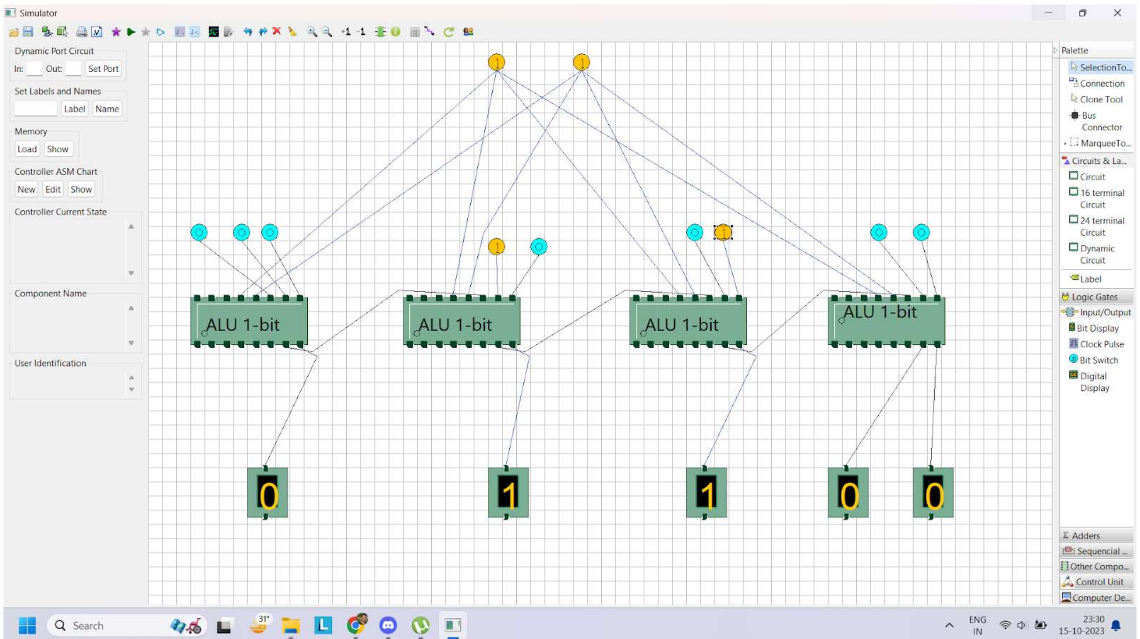


Components required :

To build any 4 bit ALU, we need :

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

Screenshots of ALU design:



Conclusion:

In conclusion, this experiment aimed to implement a 4-bit Arithmetic Logic Unit (ALU) capable of performing various operations, including AND, OR, XOR, and ADD, as specified by the control signals S3, S2, S1, and S0. The ALU design was successfully created using 1-bit ALU blocks and the corresponding control signals to achieve the desired functionality. The experiment provided valuable insights into the inner workings of an ALU and the practical application of logic gates, full adders, and multiplexers to construct complex digital circuits. By understanding and implementing the ALU design, students can grasp the fundamental principles of digital logic and arithmetic operations in computer architecture. This experiment served as a hands-on learning experience for designing and simulating digital circuits.