Programmable 1-bit ALU

You need to perform the experiment on CircuitVerse

$F_2F_1F_0$	ALU Function	Y_1	Y_0
000	0 (Zero)	-	0
001	A OR B	-	A + B
010	A AND B	-	$A \cdot B$
011	A XOR B	-	$A \oplus B$
100	A PLUS B	Carry	Sum
101	A MINUS B	Borrow	Difference
110	A PLUS B PLUS C	Carry	Sum
111	A MINUS B MINUS C	Borrow	Difference

Table 4.1 ALU Function Table

In this experiment, an Arithmetic and Logic Unit (ALU) capable of performing 8 Arithmetic/Logic functions on 1-bit operands, as listed in **Table 4.1**, will be designed, assembled and tested. Note that the first 4 functions are Logic functions generating 1-bit output Y_0, while the last four are Arithmetic functions generating 2-bit output Y_1Y_0. The ICs generally used are 74LS151(8-input multiplexers) and 74LS157(quad 2-input multiplexer), belonging to the TTL family, and CD4070(quad 2-input XOR gate) belonging to the CMOS family.

Basic information about the MUX ICs:-

The pin connections of these ICs are given in **Fig. 4.1** below. X0, X1,.....denote the data inputs and Q denotes the data output for each multiplexer. S is the select input for a 2-input multiplexer and S_2, S_1, S_0 are the select inputs for an 8-input multiplexer. Thus for a 2-input multiplexer, Q = X0 if S = 0 and Q = X1 if S =1, while for an 8-input multiplexer, the output Q = Xn (selected data input) if $S_2S_1S_0$ = n (in binary code). EN’ is the (negative-logic) output enable input, i.e. the corresponding multiplexer output is equal to the selected data input only if EN’ = 0. Q-outputs of multiplexers are LOW if EN’ = 1.

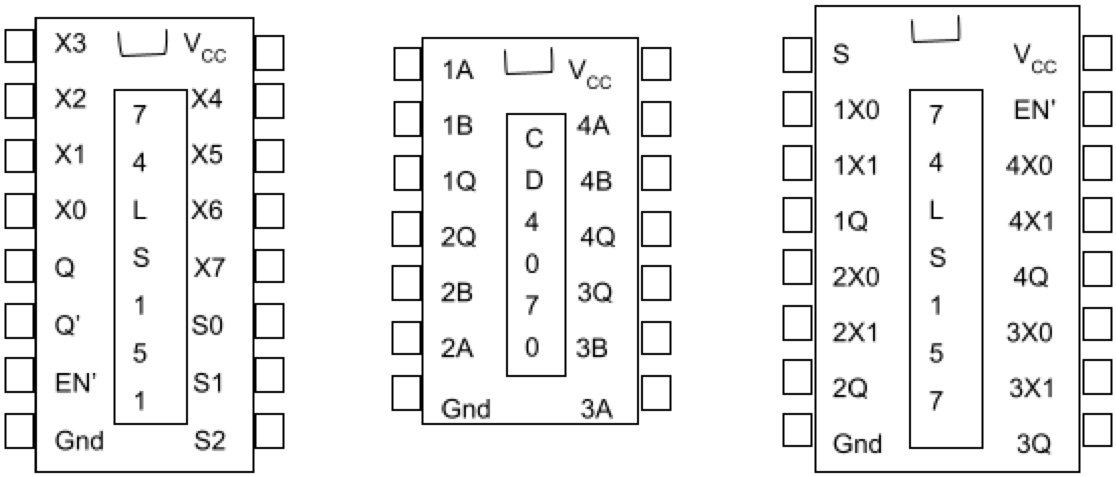


Fig 4.1 Pin Connections of the ICs used

1. You have to design this experiment on circuitverse tool.
2. The final ALU output bits $\mathbf{Y_0}$ and $\mathbf{Y_1}$ will be generated by the two 8-input multiplexers – referred to as $\mathbf{MUX_0}$ and $\mathbf{MUX_1}$ respectively. The required data, select and output enable inputs of $\mathbf{MUX_0}$ and $\mathbf{MUX_1}$ are shown in **Fig. 4.2**. Note that $\mathbf{MUX_0}$ is always enabled, while $\mathbf{MUX_1}$ is enabled only when $F_2 = 1$, i.e. for Arithmetic functions only. **This is because $\mathbf{Y_1}$ is required only to provide the CARRY/BORROW output for Arithmetic functions.**
3. Verify theoretically that $\mathbf{MUX_0}$ and $\mathbf{MUX_1}$ do generate the outputs $\mathbf{Y_0}$ and $\mathbf{Y_1}$ as required by **Table 4.1**

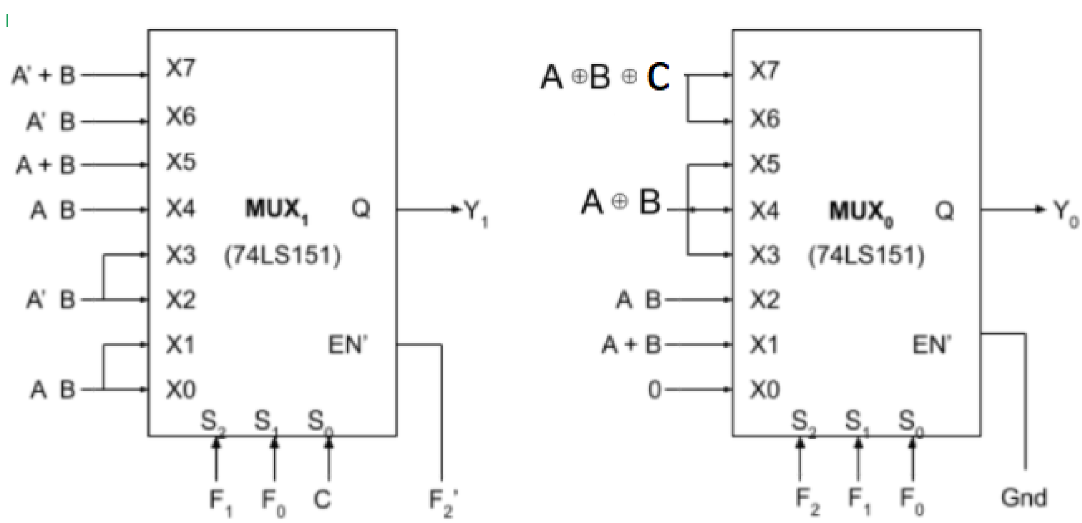


Fig. 4.2 Input connections for MUX_0 and MUX_1

4. Assemble the circuit given in **Fig. 4.3** and verify its operation by actual tabulation of the observed outputs for all combinations of values of A and B applied from two Input Switches.

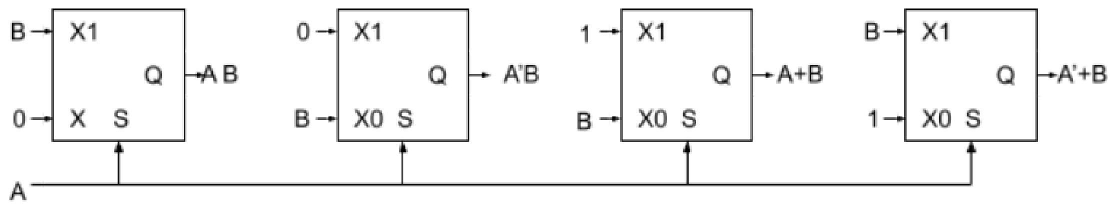


Fig. 4.3 Boolean Functions of A and B using a 2-input Multiplexer

5. Connect the same A and B inputs to the inputs of one of the gates in the XOR gate to generate **A ⊕ B**. Generate **(A ⊕ B) ⊕ C** by applying **(A ⊕ B)** and **C** to a another XOR gate. Verify the logic of these two outputs for all combinations of values of **A**, **B** and **C**.
6. Design the complete circuit by using **MUX_0** and **MUX_1**, making connections to all the inputs of **MUX_0** and **MUX_1** according to **Fig. 4.2**.
7. Applying all the combinations of the Function select inputs $F_2F_1F_0$ one by one and tabulate the observed outputs **Y_0** and **Y_1** for as many combinations of the data inputs A, B, C as possible. Verify that the tabulated results conform to the ALU functions given in **Table 4.1**.

<u>Problem Statement:-</u>

Spent fuel from nuclear reactors remains dangerously radioactive for long periods of time. This radiation must be contained. Spent fuel pools are often used to store the spent fuel underwater, because water cools the fuel down and blocks the radiation. Several conditions must be monitored and controlled to ensure that radioactive materials are not released into the environment. One facility monitors the radioactive concentrations of both the water in the pool and the air surrounding the pool. If both concentrations differ from normal levels, then the main alarm turns on, indicating a major problem. The water level of the pool is also monitored. If the water level drops below a certain threshold, or if only one of the concentrations differ from normal levels, then the minor alarm turns on.

Hint:

Design the logic circuit required to turn the alarms on and off, modelling the radioactive concentrations, water level and alarms as follows:

→ Radioactive concentrations **(inputs J (water) and K (air))**

0 – Same as normal level

1 – Differs from normal level

→ Water level (**input L**)

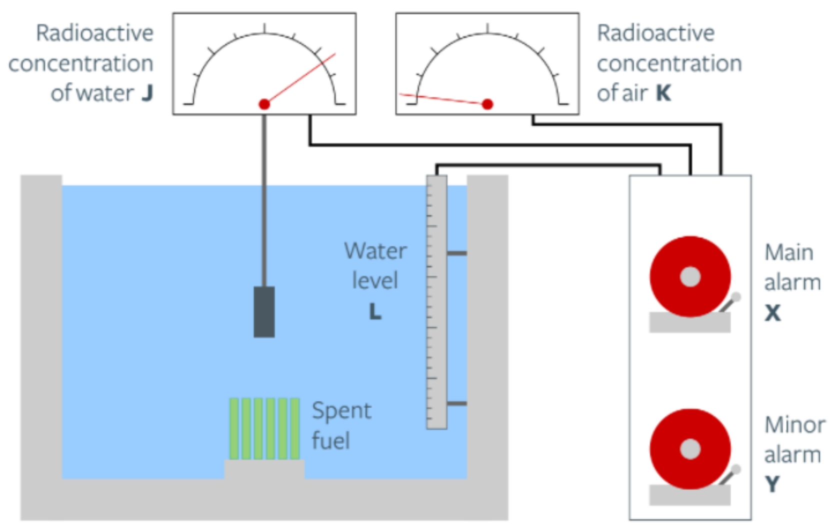
0 – Above or at safe threshold

1 – Below safe threshold

→ Alarms (**outputs X (main) and Y (minor)**)

0 – Alarm on

1 – Alarm off



Deliverables & Rubrics (Total-10 marks)

Aim and Components/ICs are ungraded but should be mentioned in the lab file. The circuitverse file has to be uploaded with the file.

1) Aim

2) Components/ICs Used

3) Pin Diagram of the ICs(follow the handout): 1.5 marks

4) Neat Circuit Diagram (Screenshot of Circuit workspace): 2 marks

5) Truth Table: 1.5 marks

6) Observations/Results: 1 marks

7) Application(atleast 2): 1.5 marks (Applications of Multiplexers)

8) Problem statement solution, circuit implementation on tinkercad (design screenshot): 2.5 marks

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