Experiment 5: Programmable ALU

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1 Objective

To design an Arithmetic and Logic Unit (ALU) capable of performing 8 Arithmetic/Logic functions on 1-bit operands, as listed in Fig. 1.

$F_2F_1F_0$	ALU Function	Y_1	Y_0
000	0 (Zero)	-	0
001	A OR B	-	A + B
010	A AND B	-	A • B
011	A EXOR B	-	A ⊕ 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

Figure 1: ALU Function Table

Note that the first 4 functions are Logic functions generate 1-bit output Y_0, while the last four are Arithmetic functions generate 2-bit output Y_1Y_0.

2 Experiment

1. The final ALU output bits Y_0 and Y_1 will be generated by the two 8-input multiplexers – referred to as MUX_0 and MUX_1 respectively. The required data, select and output enable inputs of MUX_0 and MUX_1 are shown in Fig. 2.

2. Note that MUX_0 is always enabled, while MUX_1 is enabled only when $F_2 = 1$, i.e. for Arithmetic functions only. This is because Y_1 is required only to provide the CARRY/BORROW output for Arithmetic functions.

3. Verify theoretically that MUX_0 and MUX_1 do generate the outputs Y_0 and Y_1 as required by Fig. 1.

4. Given a circuit with two 8:1 MUX, design the ALU according to the circuit diag. given in fig. 2.

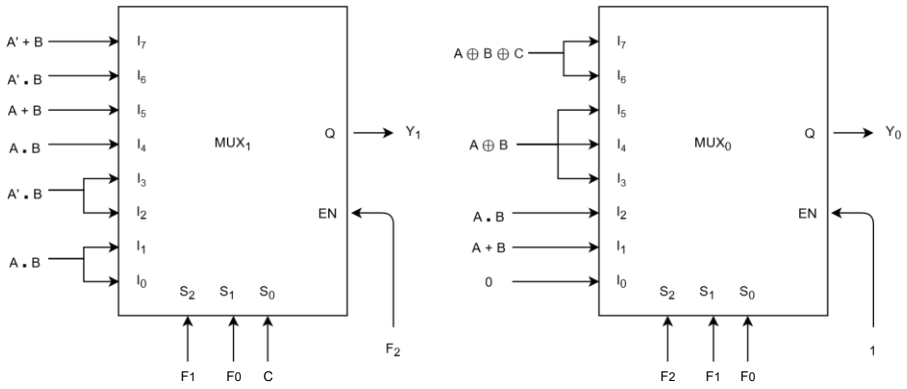

Figure 2: ALU Function Table

5. Give F_0,F_1,F_2,A,B, and C as input from an arduino.

6. Apply 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 Fig. 1.

3 Given Circuit

A circuit with two 8:1 MUX is provided to you. Tinkercad link of the circuit is here. Click on the 'Copy and Tinker' button and start using the circuit.

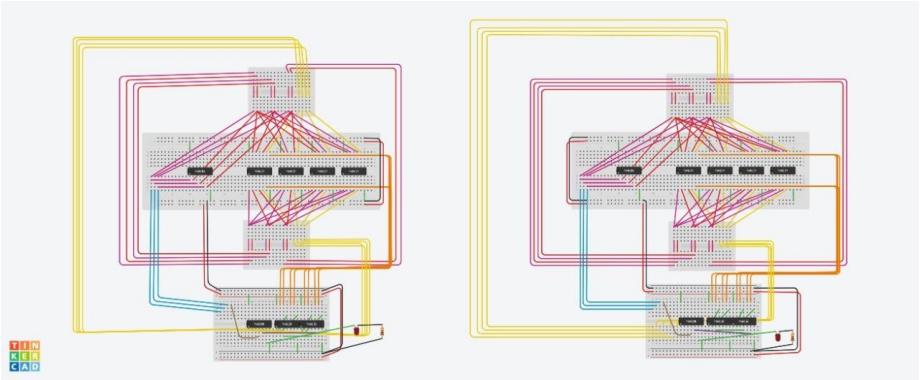

Figure 3: Two 8:1 MUX circuit

Fig. 4 below is the lowest breadboard of the MUX. This is the breadboard where you will be providing the select lines and the inputs to the MUX.

1. a_1 ... a_8 in the breadboard correspond to I_0 ... I_7 of the MUX.
2. f_1 ... f_3 in the breadboard correspond to S_0 ... S_2 of the MUX.
3. a_{12} correspond to the enable(EN) for the MUX.
4. The led correspond to the output of the MUX.
5. Remember to provide power supply form the Arduino to the MUX.

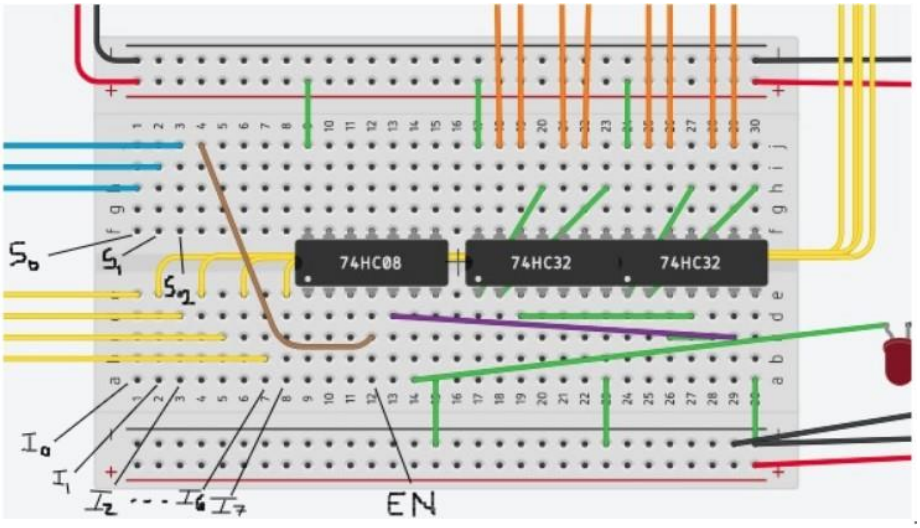

Figure 4: Two 8:1 MUX circuit