Experiment 5

Arithmetic Logic Unit (ALU)

Objectives:

To implement and test the circuits which constitute the arithmetic logic circuit (ALU).

Background Information:

The basic blocks of a computer are central processing unit (CPU), memory unit, and input/output unit. CPU of the computer is basically the same as the brain of a human being. It contains all the registers, control unit and the arithmetic logic unit (ALU). ALU considered as the most important subsystem in a digital computer. An arithmetic logic unit (ALU) is a digital circuit which performs arithmetic, logic and shift operations on two n-bit digital words. Functionally, an ALU can be divided up into three circuits: the arithmetic circuit, the logic circuit and the shift circuit.

ALU arithmetic Circuit:

The arithmetic circuit performs typical arithmetic operations such as addition, subtraction and increment or decrement by one. The basic component of an arithmetic circuit is the Full adder. By using a multiplexer to control the data inputs to the adder, it is possible to obtain different types of arithmetic operations. In this experiment we will implement a 4-bit arithmetic circuit, its logic diagram is shown in Figure 5-1. The four multiplexers select either B, B', 0 or 1 for the Y inputs of the full adder. Depending on the selection inputs and the input carry, the arithmetic circuit can generates the eight arithmetic micro operations listed in Table 5-1.

select			Input Y	Output D $D = A + Y + C_{in}$	Micro operation
S_1	S_0	C_{in}			
0	0	0	B	$A + B$	Add
0	0	1	B	$A + B + 1$	Add with Carry
0	1	0	B'	$A + B'$	Subtract with borrow
0	1	1	B'	$A - B$	Subtract
1	0	0	0	A	Transfer A
1	0	1	0	$A + 1$	Increment A by 1
1	1	0	1	$A - 1$	Decrement A by 1
1	1	1	1	A	Transfer A

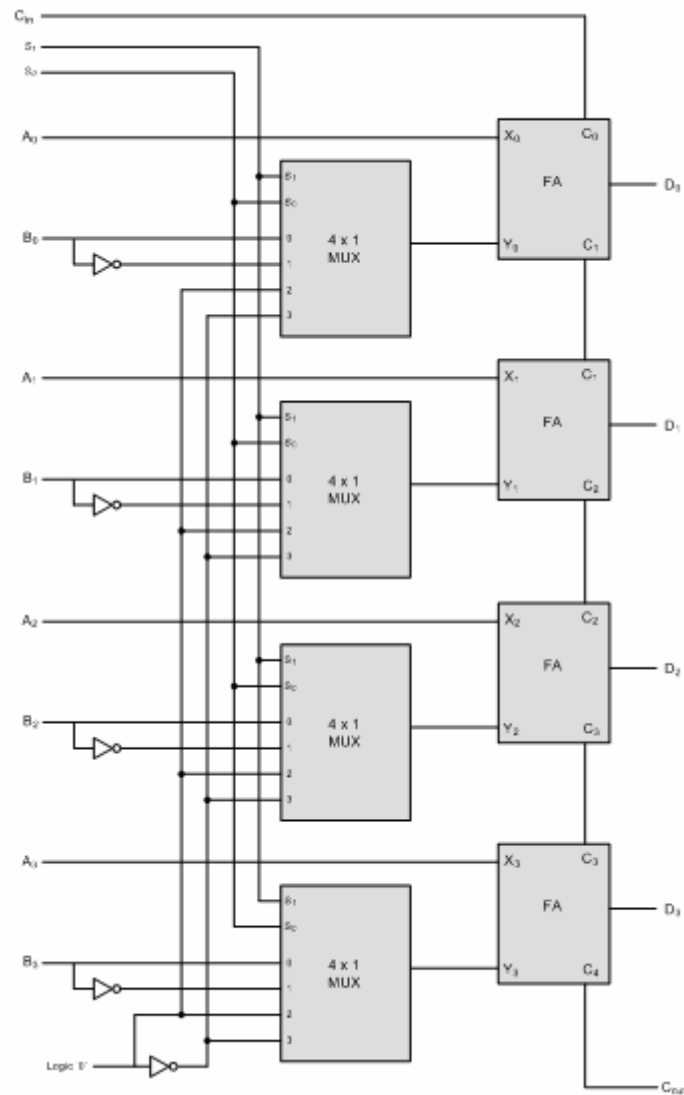Table 5-1 : Function table of the 4-bit arithmetic circuit

Figure 5-1 : Circuit diagram of the 4-bit arithmetic circuit

Equipments:

1. 4x 4-to-1 MUXs (2x 74153 chips).
2. 1x 4-bit full adder (1x 74283 chip).
3. 5X Inverters (1x 7404 chip).
4. Logic Trainer.
5. Connection leads.

Procedures:

1. Bring all IC chips necessary to build the circuit from the IC cabinet.
2. Bring some connection leads with varying lengths.
3. Derive the wiring diagram for the logic diagram shown in Figure 5-1.
4. Insure that the power switch of the IC trainer is turned off.

5. Plug the IC chips into the proper sockets.

6. Connect the voltage supply and ground lines to the chips.

7. Use the connection leads to connect the circuit according to the derived wiring diagram.

8. Once all connections have been done, turn on the power switch of the IC trainer .

9. Verify the circuit function for all micro operations listed in table 5-1.

10. After finishing the experiment, turn off the power switch, disconnect the wires, and take out the IC chips from the trainer.

ALU Logic Circuit:

The ALU, logic circuit performs the basic logic micro operations: NOT, AND, OR and XOR. From these four micro operations all known logic micro operations can be derived. Figure 5-2 shows the logic diagram for one stage of logic circuit. The four gates generates the four logic operations and the multiplexer select the desired operation as shown in Table 5-2.

S_1	S_0	Output	Operation
0	0	AB	AND
0	1	A + B	OR
1	0	A $\oplus$ B	XOR
1	1	A'	Complement

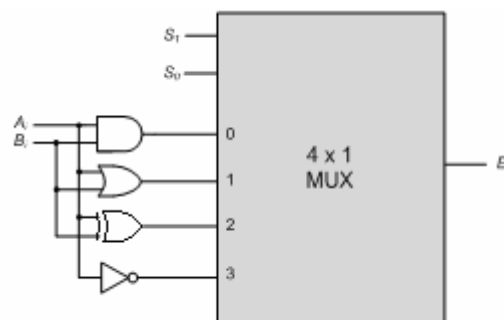Table 5-2 : Function table of the 2-bit logic circuit

Figure 5-2 : Circuit diagram of the 2-bit logic circuit

Equipments:

1. 1x 4-to-1 MUXs (1x 74153 chips).

2. 1x AND Gate (1x 7408 chip).

3. 1x OR Gate (1x 7432 chip).

4. 1x XOR Gate (1x 7486 chip).

5. 1x NOT Gate (1x 7404 chip).

6. Logic Trainer.

7. Connection leads.

Procedures:

1. Bring all IC chips necessary to build the circuit from the IC cabinet.
2. Derive the wiring diagram for the logic diagram shown in Figure 5-2.
3. Insure that the power switch of the IC trainer is turned off.
4. Plug the IC chips into the proper sockets.
5. Connect the voltage supply and ground lines to the chips.
6. Use the connection leads to connect the circuit according to the derived wiring diagram.
7. Once all connections have been done, turn on the power switch of the IC trainer.
8. Verify the circuit function.
9. After finishing the experiment, turn off the power switch, disconnect the wires, and take out the IC chips from the trainer.

ALU Shift Circuit:

Shift circuit used to perform the shift micro operations. The contents of a register can be shifted serially to the left or to the right. The shift circuit contains multiplexers as shown in Figure 5-3. when the select line is 0 the 4-bit input data are shifted right. When the select line is 1 the input data are shifted left. There are two serial inputs one for shift left and other one for shift right. The function table shows the outputs of the multiplexers in each case.

S	H_3			
	H_3	H_2	H_1	H_0
0	I_R	A_3	A_2	A_1
1	A_2	A_1	A_0	I_L

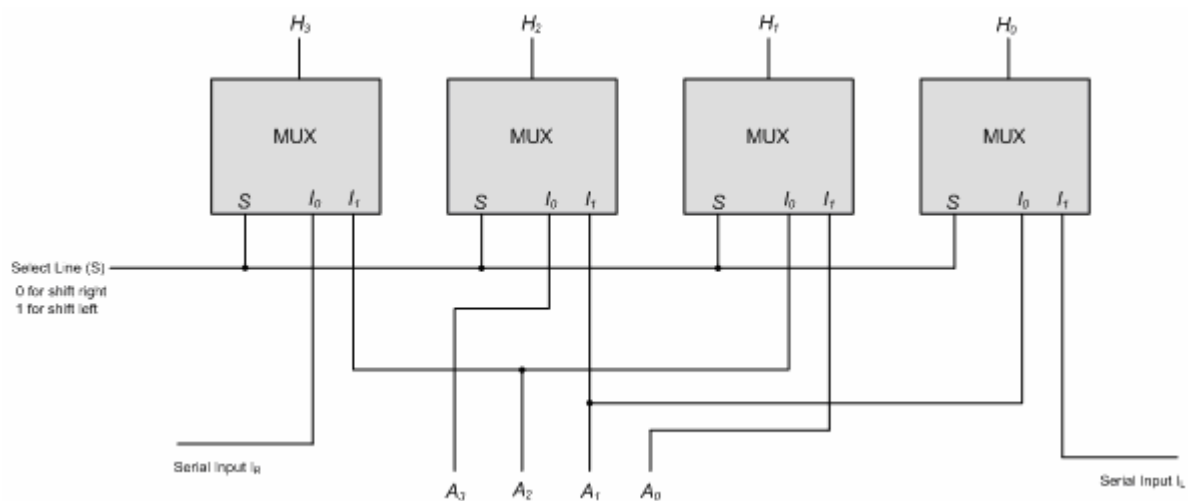Table 5-3 : Function table of the 4-bit shift circuit

Figure 5-3 : Circuit diagram of the 4-bit shift circuit

Equipments:

1. 4x 2-to-1 MUXs (1x 74157 chip).
2. Logic Trainer.
3. Connection leads.

Procedures:

1. Bring the IC chip necessary to build the circuit from the IC cabinet.
2. Derive the wiring diagram for the logic diagram shown in Figure 5-3.
3. Insure that the power switch of the IC trainer is turned off.
4. Plug the IC chip into the proper socket.
5. Connect the voltage supply and ground lines to the chip.
6. Use the connection leads to connect the circuit according to the derived wiring diagram.
7. Once all connections have been done, turn on the power switch of the IC trainer.
8. Verify the circuit function according to its function table.
9. After finishing the experiment, turn off the power switch, disconnect the wires, take out the IC chip from the trainer, put back everything you have used, close IC trainer and clean your table.