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W13 DE 2.1.3 AOI Logic Implementation

Read the introduction in each section carefully.

INTRODUCTION

Would you pay $199 for a written specification for an MP3 player? Would you pay $299 for the schematics for a cell phone? Of course not. You don't pay for the specifications or the schematics; you pay for the product itself.

You are not quite to the point where you can design an game console or a cell phone, but you can design AOI logic circuits. In this activity, you will learn how to implement AOI logic circuits from logic expressions. The logic expressions will be in either Sum-of-Products (SOP) or Products-of-Sum (POS) form.

EQUIPMENT

- Computer with Circuit Design Software (CDS)
- Breadboarding Hardware *or* Digital MiniSystem
- Integrated Circuits (74LS04, 74LS08, 74LS32)
- 22-gauge solid wire
- Multipurpose Wire Stripper

Procedure

Let's examine the process of implementing an AOI logic circuit by designing a circuit for the relatively simple Sum-of-Products (SOP) logic expression F_1.

$$F_1 = A\,\overline{C} + \overline{A}\,C + A\,\overline{B}\,C$$

1. In your notebook, draw an AOI circuit that implements the logic expression F_1. For this implementation, you may assume that AND and OR gates are available with any number of inputs.

F_1 – I

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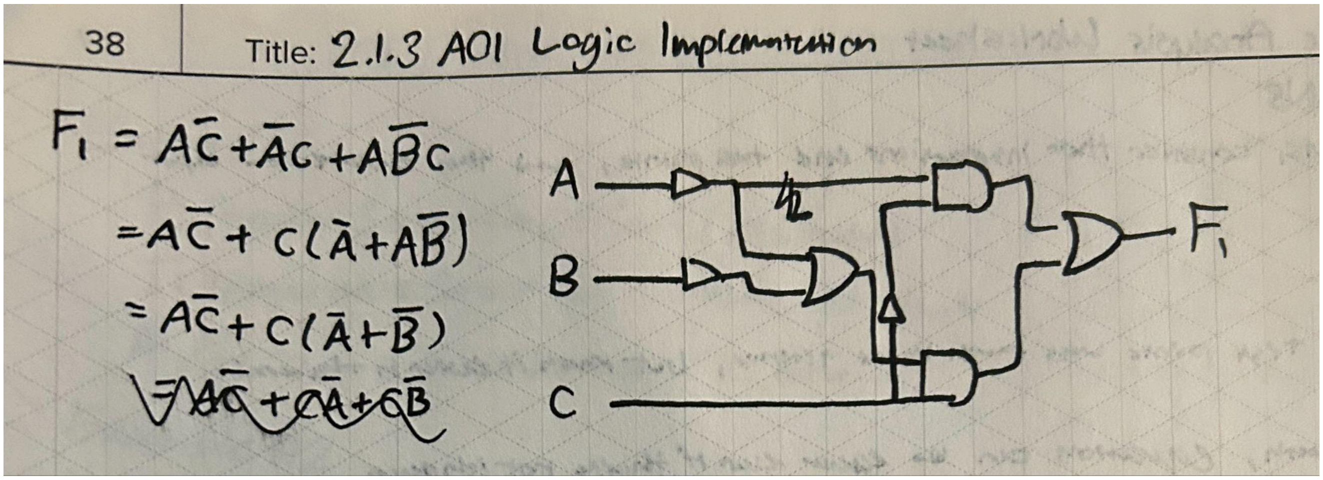
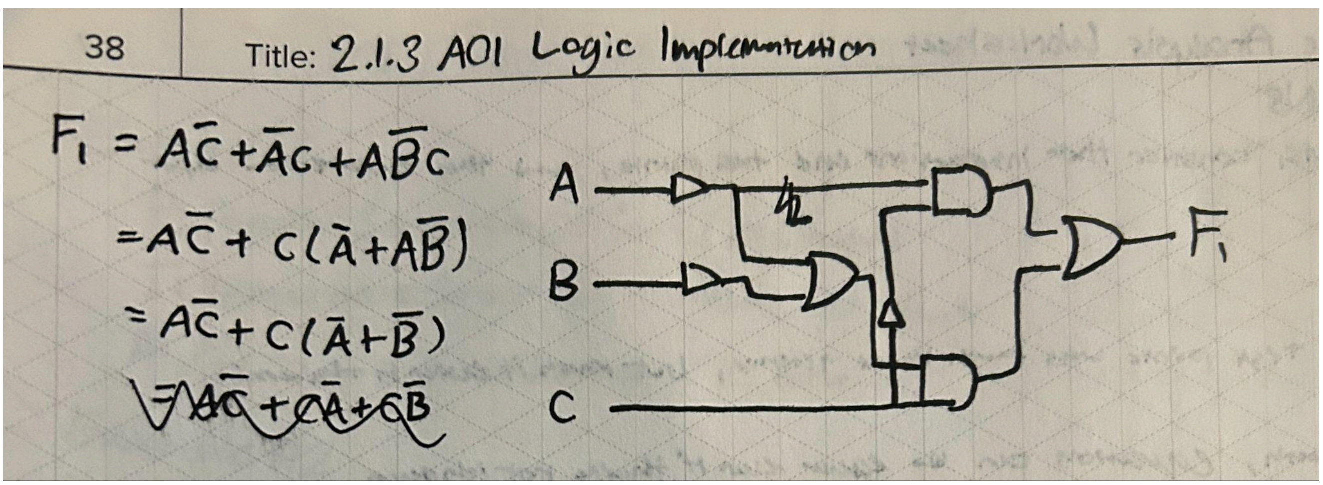


2. Re-implement the circuit assuming that only 2-input AND gates (74LS08), 2-input OR gates (74LS32), and inverters (74LS04) are available. Draw this circuit in your notebook.
F_1 – II



3. Using the CDS, enter and test the logic circuit that you designed. Use switches for the inputs ***A, B,*** and ***C*** and a probe or LED circuit for the output ***F_1***. Verify that the circuit is working as expected. Print a copy of the circuit and attach it in your E-Portfolio.
F_1 – CDS

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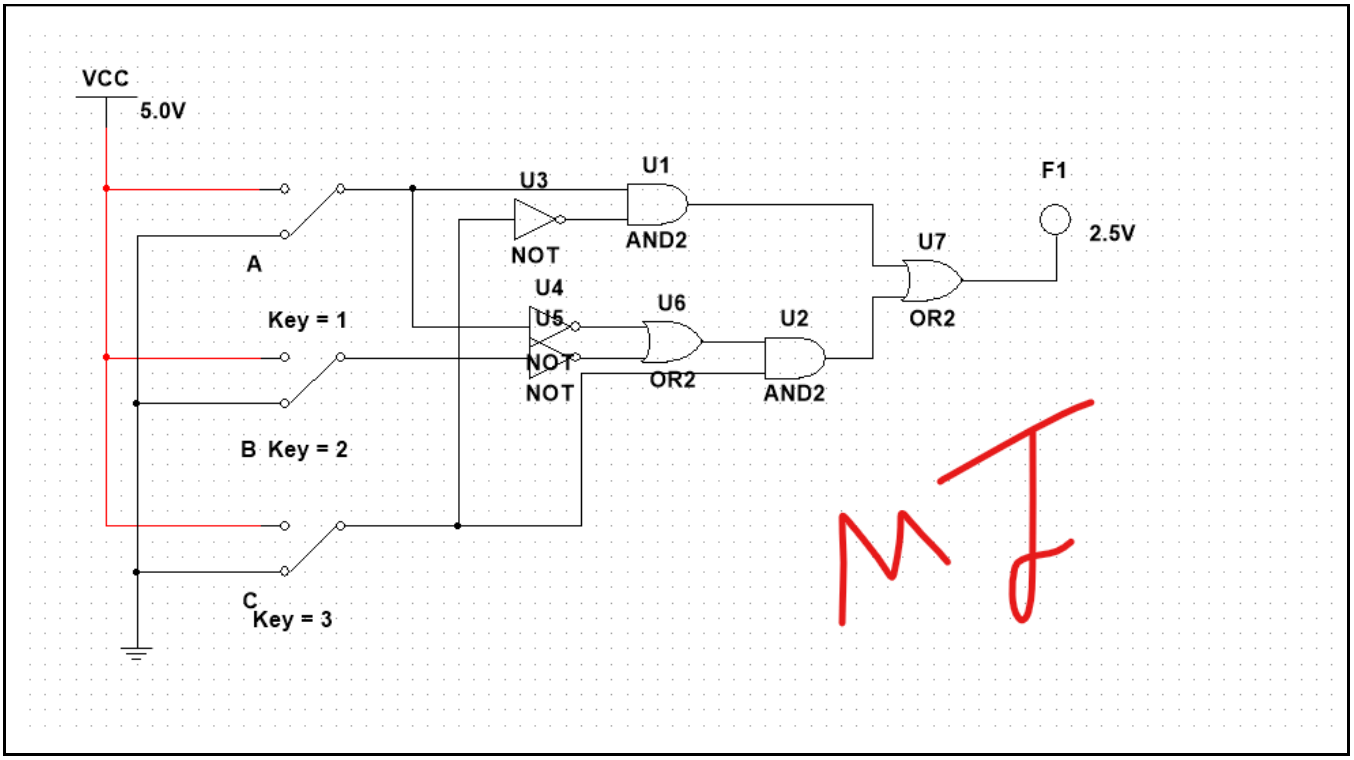

Distance Learning Support

Use the following components to complete your circuit in **Multisim Live**.

- In place of VCC, the **Digital Constant** power supply found in the **Digital** subpalette which can be turned on (1) or off (0)
- Also in the **Digital** subpalette, the **AND**, **OR**, and **Inverter** gates
- From the **Analysis and annotation** palette, **Digital** probes

Helpful tip: Recall that you can select multiple components by holding down the control key (CTLR) and dragging the cursor over the components.

$$F_1 = A\,\overline{C} + \overline{A}\,C + A\,\overline{B}\,C$$

4. Using the Digital MiniSystem, build and test the logic circuit that you designed and simulated. Verify that the circuit is working as expected and the results match the results of the simulation.

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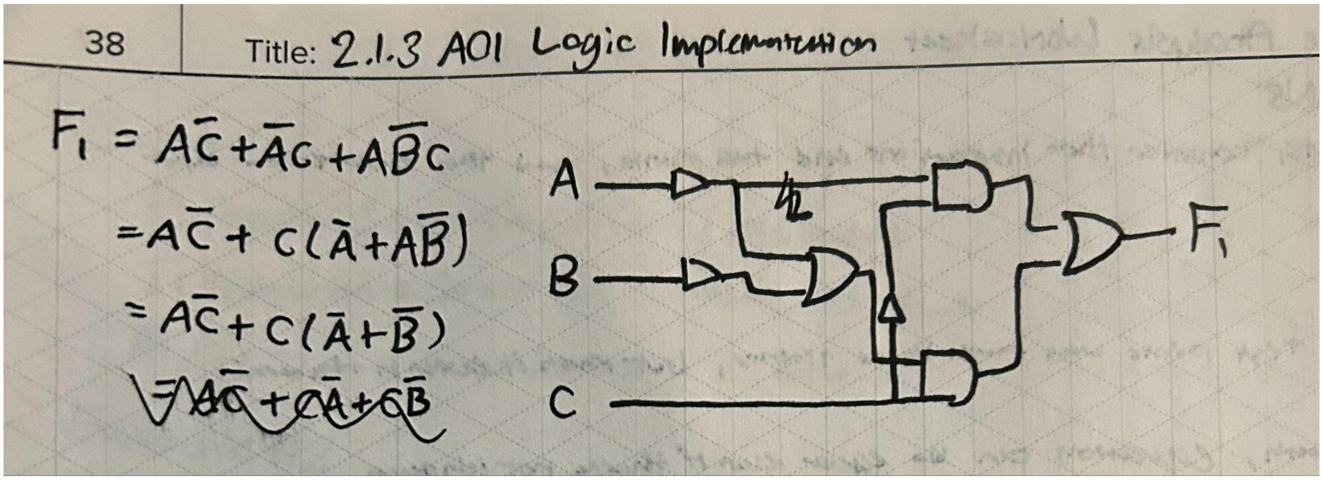
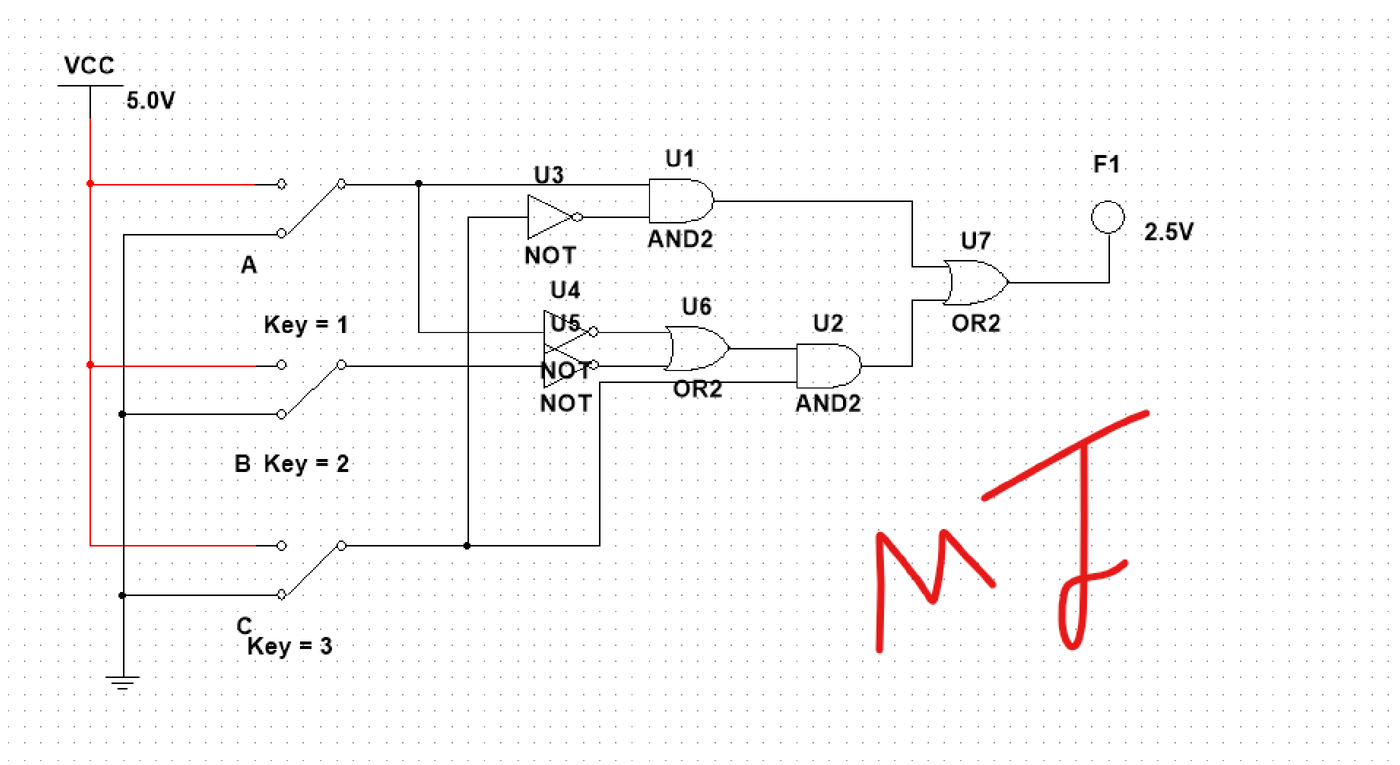
Circuit Sketch



Multisim Design



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Distance Learning Support

Check with your teacher whether you will be physically breadboarding your circuit. If you are using **Tinkercad**, you will need the following components.

- Three **Slideswitches** with resistors wired as shown. Connect the right-side column to your circuit to enable it when you move the switch to the right.
- Hex Inverters (74HC04)
- Quad AND gates (74HC08)
- Quad OR gates (74HC32)
- LED with resistor for testing

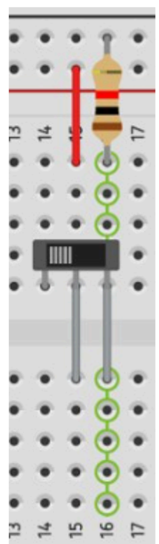

Figure 1. Circuit

Though they are less frequently used, in later activities we will see that occasionally, logic expressions in the Product-of-Sums (POS) form are easier to implement than SOP equations. For practice, let's implement an AOI circuit for the logic expression F_2.

$$F_2 = (A + C) \bullet (\overline{A} + \overline{B} + \overline{C})$$

5. In your notebook, draw an AOI circuit that implements the logic expression F_2. For this implementation, you may assume that AND and OR gates are available with any number of inputs.

F_2 – I

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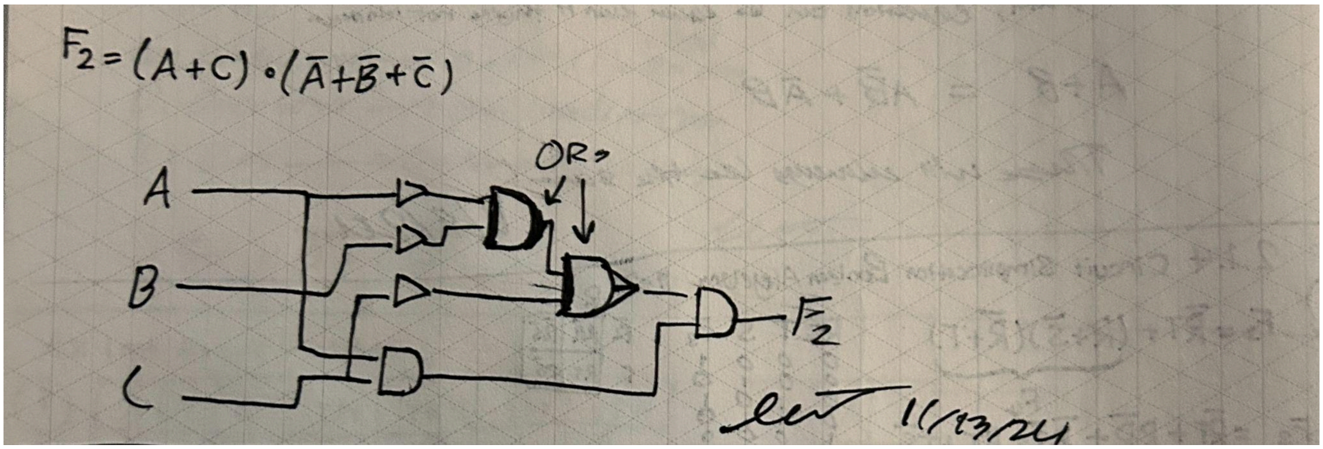
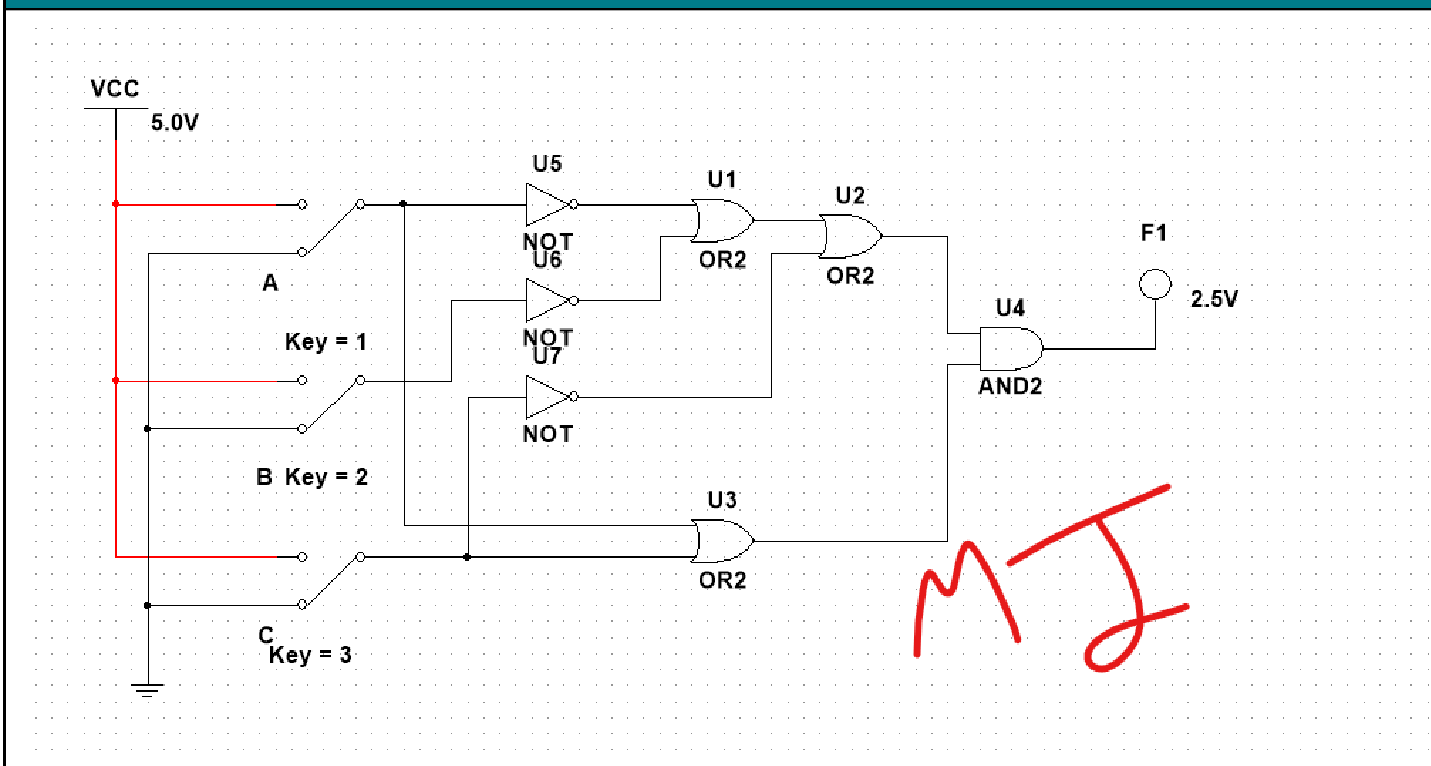
Circuit Sketch



Multisim Design



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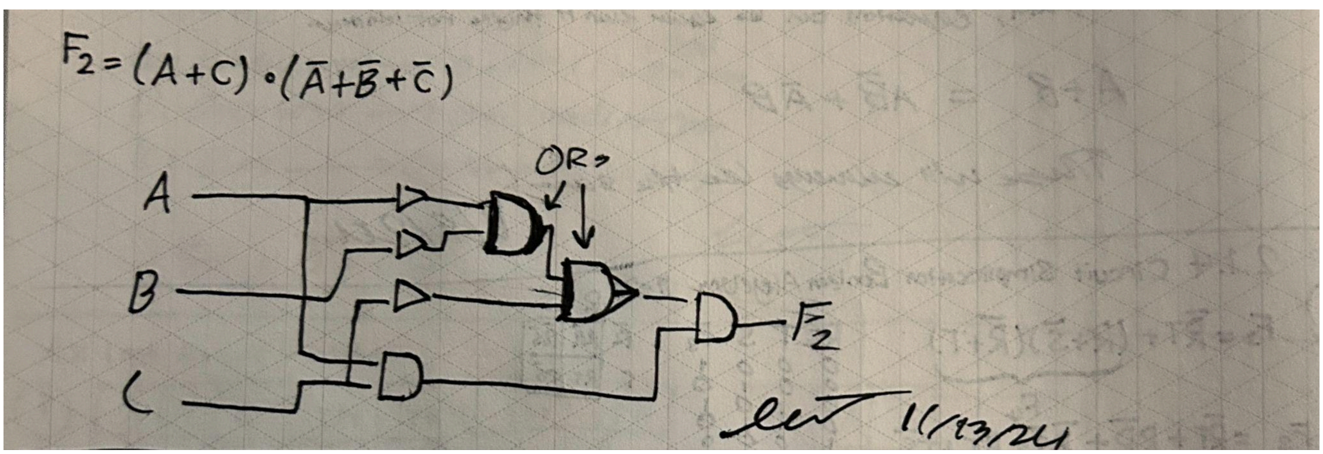
6. Re-implement the circuit assuming that only 2-input AND gates (74LS08), 2-input OR gates (74LS32), and inverters (74LS04) are available. Draw this circuit in your notebook.
F_2 – II

Circuit Sketch



Multisim Design

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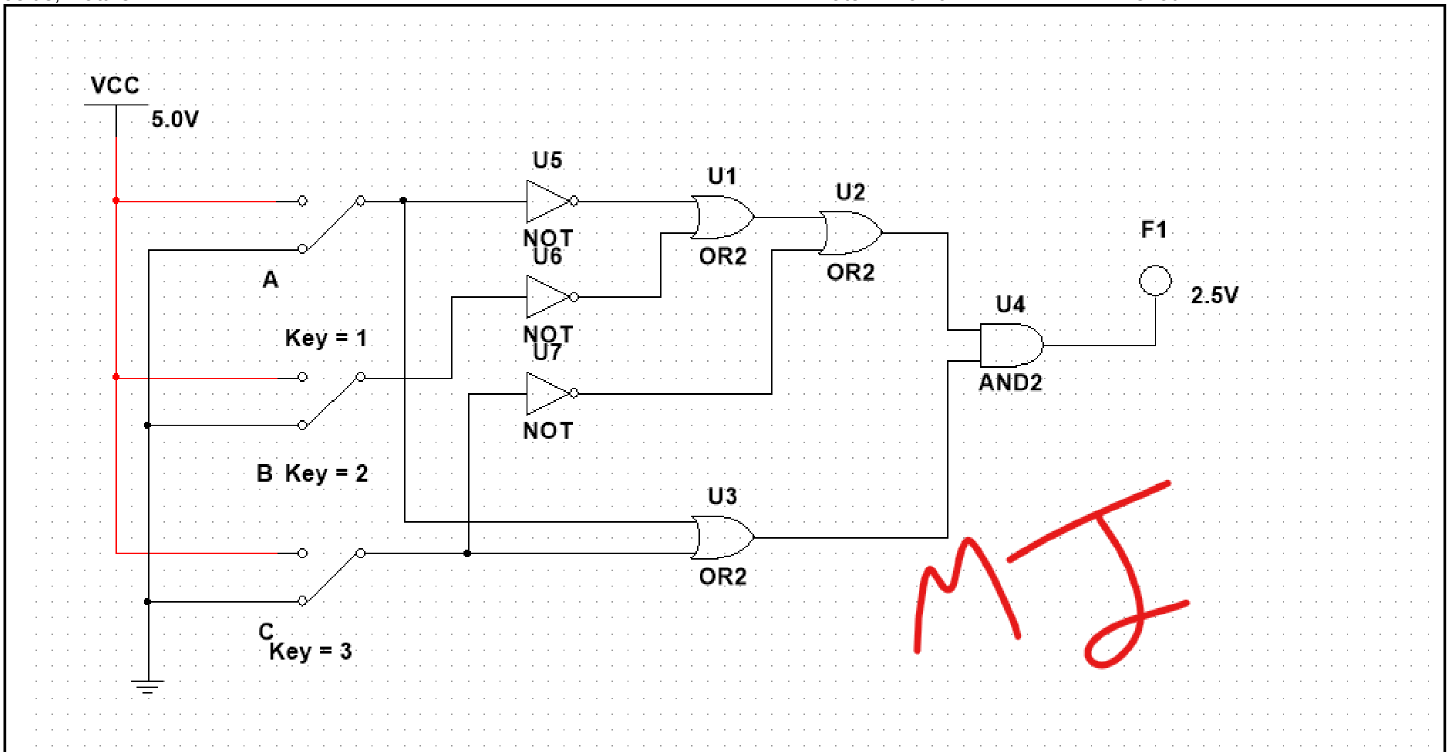

7. Using the CDS, enter and test the logic circuit that you designed. Use switches for the inputs ***A, B,*** and ***C*** and a probe or LED circuit for the output F_2. Verify that the circuit is working as expected. Print a copy of the circuit and attach in your notebook.

F_2 – CDS

Circuit Sketch

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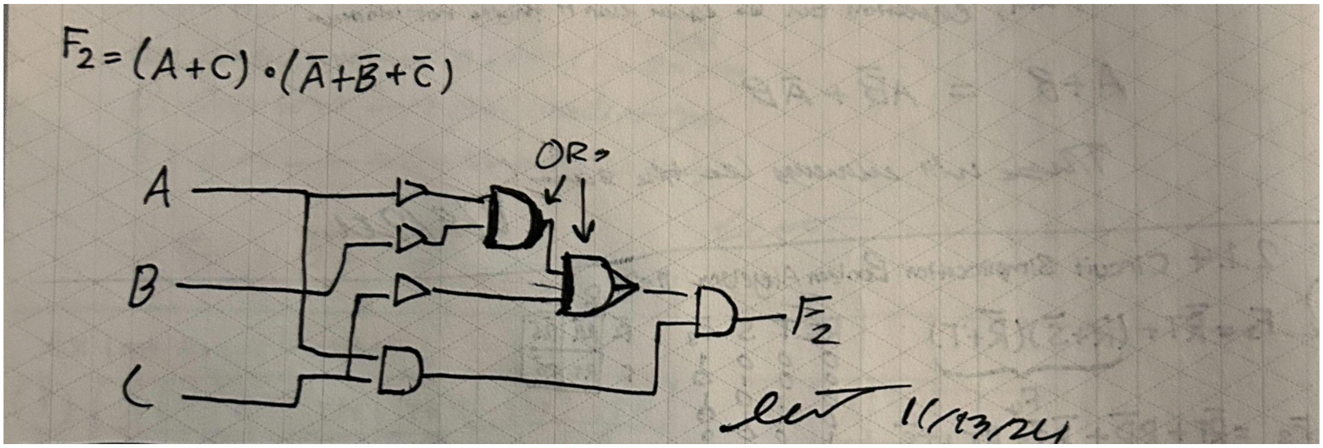
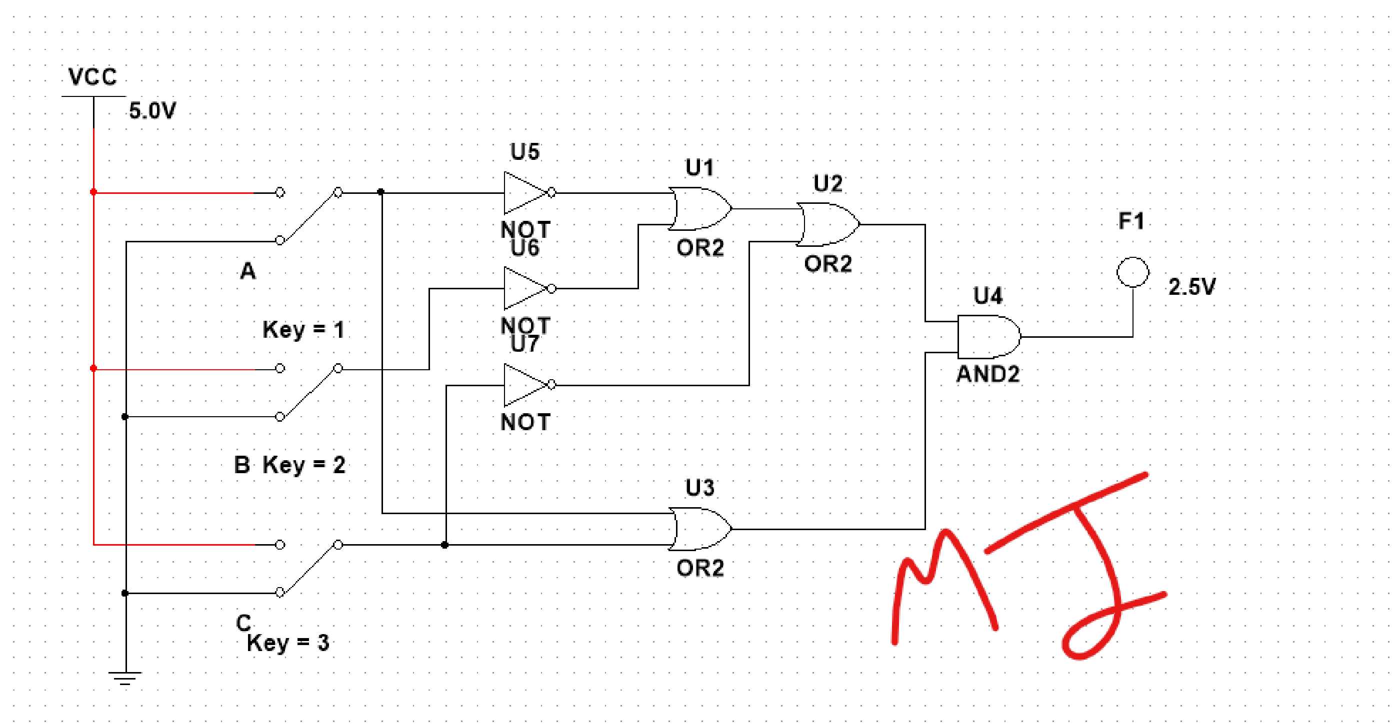


Multisim Design



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CONCLUSION

1 The two circuits shown below are equivalent, meaning that they both produce the same output, Minterm = WXYZ.

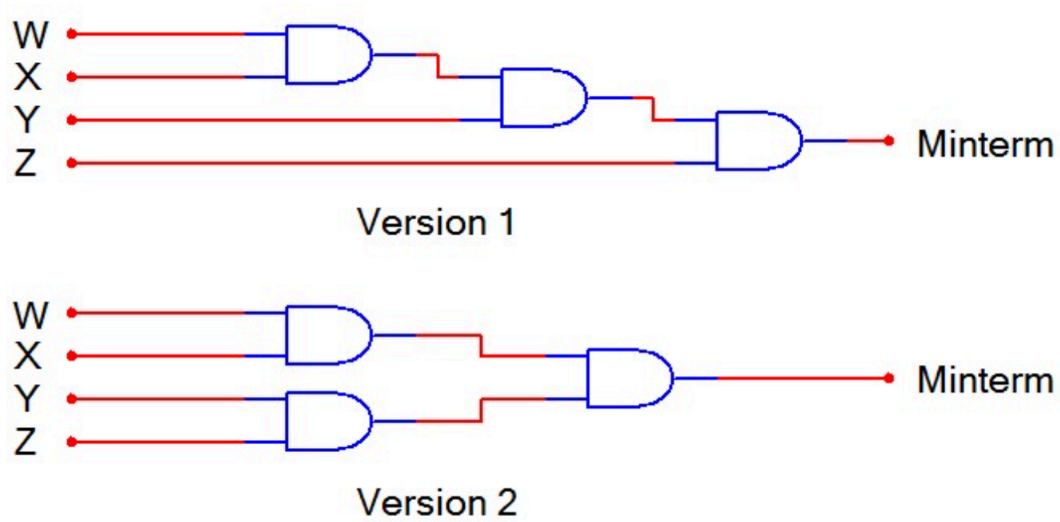

Figure 2. Logic Circuit

1. Analyze each circuit to prove that they both produce the output Minterm = WXYZ.

2. Since the two versions produce the same output and require the same number of gates to implement, is one version any better than the other?

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2 Below are two equivalent circuits. One was implemented from an SOP logic expression and the other from the equivalent POS form.

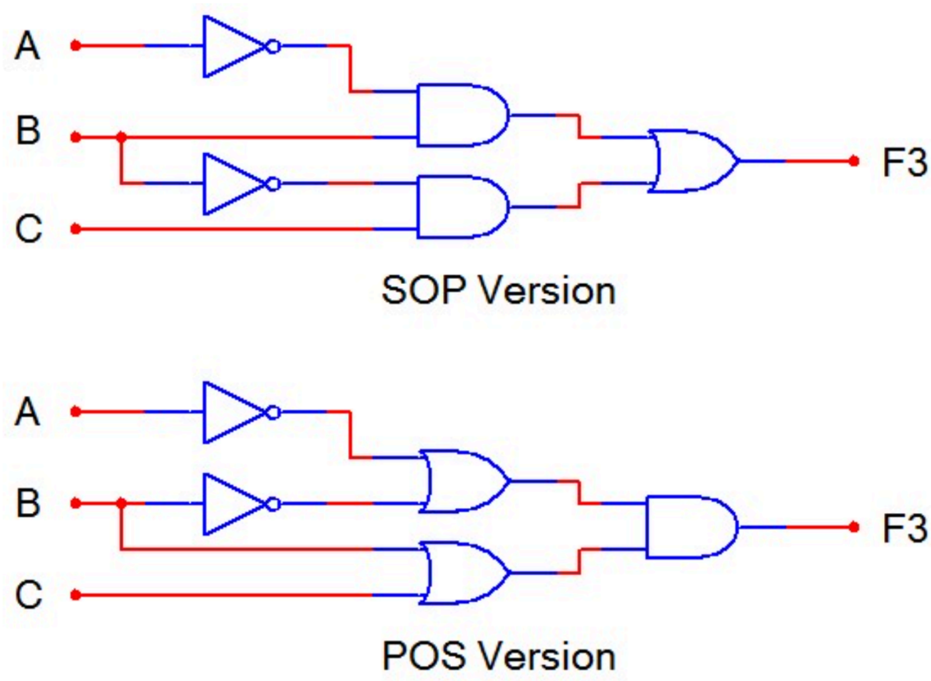

Figure 3. Logic Circuits

A. First, analyze the SOP version to determine the logic expression for F_3 in SOP form. Use this expression to generate a truth table for the circuit.
B. Now analyze the POS version to determine the logic expression for F_3 in POS form. Use this expression to generate a truth table for the circuit.
C. How do the two truth tables compare? Is the column for F_3 the same for both? They should be. If they are not the same, review your work and make any necessary corrections.
D. Since the truth tables are the same for F_3, what could be said about the two logic expressions?