9. Draw the schematic of a circuit that will perform th operations in the following logical equation: f = C+DF.

10. Draw and complete a truth table for the equation from question nine.

11. Name the combinational logic circuits .

_____

_____

12. What are combinational logic circuits used for ?

_____

13. Why have digital integrated circuits become so popular ?

_____

_____

LAB EXERCISE 3.1
The NOT Circuit (Inverter)

Objectives

After completion of this experiment you will understand the operation of logic inverters (NOT gates). You will be able to use the 74LS04 IC and explain its operation.

Materials

LD-2 Logic Designer

74LS04 Hex Inverter

Jumper Wires

TTL Data Book

Procedure

This section will begin your experiments with logic gates. You will learn some general characteristics of logic circuits then study the 74LS04 TTL hex inverter.

All logic circuits will have connections for power and ground. Logic circuits are usually seen as Dual Inline Package

Integrated Circuits known as DIP ICs. The term dual inline package describes the pin arrangement for the integrated circuit inputs and outputs.

All DIP ICs have one end or corner marked in a special way. This marking is used to show integrated circuit pin orientation. With the marked end of the IC facing away from you the pins are numbered counterclockwise from the upper left corner. Figure 3-8 shows how ICs are marked and how the pins are numbered.

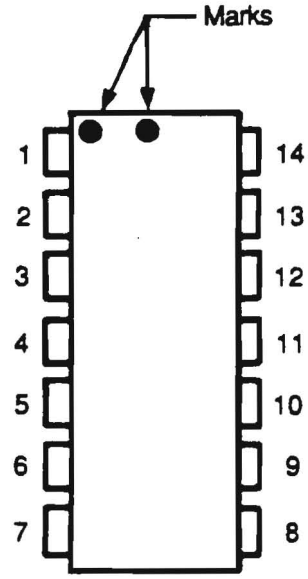
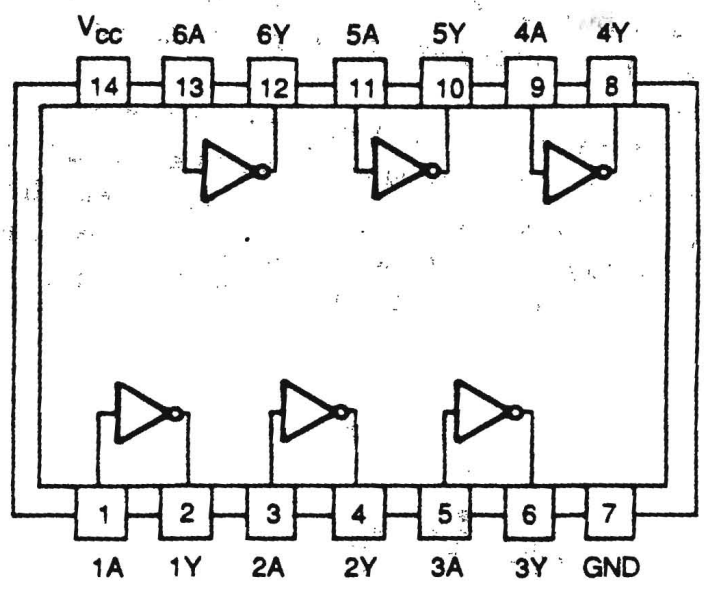


FIGURE 3-8. IC Orientation and Pin Numbering.

The ICs used in this experiment are TTL ICs. This means the voltage of the two logic states are 0 and 5 volts. A large number of compatible integrated circuits have been manufactured as the 7400 series of TTL ICs. Correct connection of power and ground pins is crucial to circuit operation. Many 14 pin DIP ICs use pin 7 for ground and pin 14 for Vcc. Some 14 pin DIPs use pin 11 for ground and pin 4 for Vcc. Most 16 pin DIP ICs use pin 8 for ground and pin 16 for Vcc. If you connect the power and ground connections incorrectly the IC will be destroyed. For this reason, a basing diagram of all ICs used in experiments is provided. The basing diagram explains all connections to an IC and uses schematic symbols to indicate logic functions performed by the circuit. A basing diagram for the 74LS04 hex inverter is shown in Figure 3-9.

iURE 3-9. Basing Diagram for 74LS04 IC.



If you have trouble during the experiment, remove power from the IC and check circuit wiring. Consult with your instructor if after repeated attempts to correct the problem fail.

1. Place 1 74LS04 IC onto the LD-2 breadboard.

2. Use the basing diagram of the 74LS04 to locate the power and ground pins.

3. Connect pin 7 to ground and pin 14 to +5 VDC. Power and ground connections are provided on the right most two-row breadboard section of the LD-2.

4. Connect pin 1 to PB1. PB1 is on the left most two-row breadboard. There are two PB1 connections. You should use the left one.

5. Connect pin 1 to L1 on the right most two-row breadboard. This will allow monitoring the inverter input.

6. Connect pin 2 to L2 (next to L1). This allows monitoring the inverter output.

7. Check circuit wiring. When you are certain that the circuit is correctly wired, connect power to the LD-2 and position the On/Off switch (the right corner of the LD-2 near the power plug) to on. Two lights should be on. D1 indicates power is on. L1 indicates the state of the inverter input. If both lights are off, disconnect power and check the circuit wiring particularly power and ground. If D1 is on and L1 is off turn the power off using the On/Off switch. Check circuit wiring paying careful attention to pins 1 and 2. If no problem is noted proceed to step 2. If you had problems retry step one.

8. Record the states of L1 and L2 (NOTE: an on light indicates a logic one). 1 0

9. Push PB1, the upper pushbutton at the lower left side of the LD-2. Record the states of L1 and L2. 0 0

10. Turn off power. Leave the 74LS04 IC connected till after you have finished the following questions.

Questions

1. Construct a truth table for the 74LS04 hex inverter.

2. Why is the 7404 called a hex inverter ? (hint: look at the basing diagram)

_____

_____

3. Are the lights L1 and L2 ever on simultaneously ?

LAB EXERCISE 3.2
The AND Gate

Objectives

In this laboratory you will learn the use of the 74LS08 quad two-input AND gate. You will observe and record the AND gate's logic characteristics.

Materials

LD-2 Logic Designer

74LS08 Quad Two-input AND Gate

Jumper Wires

TTL Data Book

Procedure

1. Insert the 74LS08 IC into the breadboard.

2. Wire pin 7 to ground and pin 14 to Vcc.

3. Wire S1 on the left two-row breadboard to pin 1 on the 74LS08 and L1 on the right two-row breadboard. This allows setting the state of pin 1 with switch S1 and observing it's state on L1.

4. Wire S2 to pin 2 on the 74LS08 and to L2. This allows setting and observing the state of pin 2.

5. Wire pin 3 on the 74LS08 to L3. This allows observation of the AND gate output.

6. Place S1 and S2 in their off state (toward the words "LOGIC SWITCHES" printed on the LD-2 circuit board).

7. Connect and turn on power. D1 should be lit. If D1 is not lit or other lights are on, then turn off power and recheck circuit interconnection.

8. Move S1 to ON. L1 should light. If L1 does not light check wiring to pins 1 and 2.

9. Turn S1 to OFF and S2 to ON. L2 should light.

10. Now use S1 and S2 to determine the truth table for the 74LS08. Record your results. Observe the circuit output on L3.

11. Remove power from the LD-2 and remove the circuit used for this experiment.

LAB EXERCISE 3.3
The OR Gate

Objectives

In this laboratory you will learn about the 74LS32 two-input OR gate.

Materials

LD-2 Logic Designer

74LS32 Quad Two-input OR Gate

Jumper Wires

TTL Data Book

Procedure

1. Insert the 74LS32 IC into the breadboard.

2. Wire pin 7 to ground and pin 14 to Vcc.

3. Wire S1 on the left two-row breadboard to pin 1 on the 74LS32 and L1 on the right two-row breadboard. This allows setting the state of pin 1 with switch S1 and observing it's state on L1.

4. Wire S2 to pin 2 on the 74LS32 and to L2. This allows setting and observing the state of pin 2.

5. Wire pin 3 on the 74LS32 to L3. This allows observation of the OR gate output.

6. Place S1 and S2 in their off state (toward the words "LOGIC SWITCHES" printed on the LD-2 circuit board).

7. Connect and turn on power. D1 should be lit. If D1 is not lit or other lights are on, then turn off power and recheck circuit interconnection.

8. Place S1 in the ON position. L1 and L3 should light.

9. Place S1 to OFF and S2 to ON. L2 and L3 should light.

10. Place S2 to OFF. Use the switches and lights to determine the truth table for the 74LS32. Record your observations.

11. Remove power from the LD-2 and remove the circuits used for this laboratory.

LAB EXERCISE 3.4
The NAND Gate

Objectives

In this laboratory you will learn the operation of the 74LS00 two-input NAND gate.

Materials

LD-2 Logic Designer

74LS00 Quad Two-input NAND Gate

Jumper Wires

TTL Data Book

Procedure

1. Insert the 74LS00 IC into the breadboard.

2. Wire pin 7 to ground and pin 14 to Vcc.

3. Wire S1 on the left two-row breadboard to pin 1 on the 74LS00 and L1 on the right two-row breadboard. This allows setting the state of pin 1 with switch S1 and observing it's state on L1.

4. Wire S2 to pin 2 on the 74LS00 and to L2. This allows setting and observing the state of pin 2.

5. Wire pin 3 on the 74LS00 to L3. This allows observation of the NAND gate output.

6. Place S1 and S2 in their off state (toward the words "LOGIC SWITCHES" printed on the LD-2 circuit board).

7. Connect and turn on power. D1 and L3 should be lit.

8. Move S1 to the ON position. L1 should light.

9. Move S1 to OFF and S2 to ON. L2 should light.

10. Move S1 to OFF. Use S1, S2 and L3 to determine the truth table of the 74LS00 IC. Record your observations here.

11. Remove power and then disassemble the laboratory circuit.

LAB EXERCISE 3.5
The NOR Gate

Objectives

In this experiment you will learn the use of the 74LS02 two-input NOR gate.

Materials

LD-2 Logic Designer

74LS02 Quad Two-input NOR Gate

Jumper Wires

TTL Data Book

Procedure

1. Insert the 74LS02 IC into the breadboard.

2. Wire pin 7 to ground and pin 14 to Vcc.

3. Wire L1 on the right two row breadboard to pin 1 on the 74LS02. This allows observing the state of pin 1 (NOR gate output) with L1.

4. Wire S2 to pin 2 on the 74LS02 and to L2. This allows setting and observing the state of pin 2.

5. Wire pin 3 on the 74LS00 to L3 and S3. This allows setting and observing the state of pin 3.

6. Place S3 and S2 in their off state (toward the words "LOGIC SWITCHES" printed on the LD-2 circuit board).

7. Connect and turn on power. D1 and L1 should be lit.

8. Place S2 to ON. L2 should light (L1 will go OFF).

9. Turn S2 OFF and S3 ON. L3 should light.

10. Turn S3 OFF. Use S2, S3 and L1 to determine the truth table of the 74LS02 IC. Record your observations.

11. Remove power and disassemble the laboratory circuit.

LAB EXERCISE 3.6 Using NAND and NOR Gates

Objectives

In this experiment you will confirm that NOR and NAND gates can be used to perform any logic function.

Materials

LD-2 Logic Designer

74LS02 Quad Two-input NOR IC

74LS00 Quad Two-input NAND IC

Jumper Wires

TTL Data Book

Procedure

1. Install the 74LS02 IC on the breadboard.

2. Wire ground to pin 7 and Vcc to pin 14.

3. Wire S2 to pin 2 and S3 to pin 3.

4. Wire S2 to L2 and S3 to L3.

5. Wire pin 1 to pins 5 and 6. Shorting pins five and six

causes gate 2 of the quad IC to act as an inverter. (You may want to convince yourself of this.)

6. Wire pin 6 to L6. This is the inverter input.

7. Wire pin 4 to L4. This is the inverter and overall circuit output.

8. Turn S2 and S3 to OFF.

9. The schematic for the circuit you have just constructed is shown in Figure 3-10.

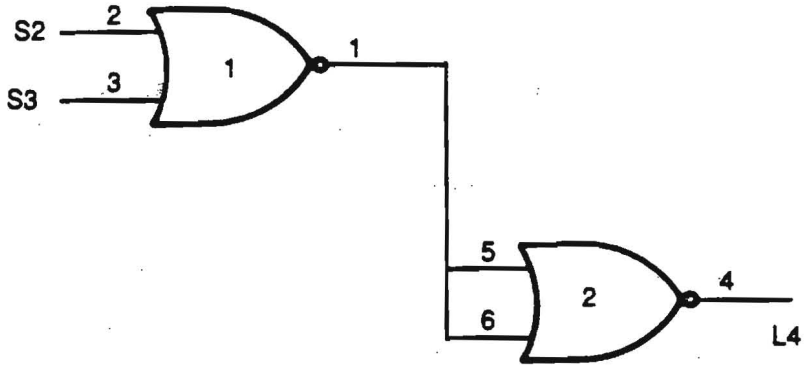


FIGURE 3-10. Circuit Schematic.

10. Turn on power. D1 and L6 should light.

11. L2 and L3 monitor the state of S2 and S3. L6 monitors the NOR gate output. L4 monitors the circuit output. Use S2, S3 and L4 to create a truth table for this circuit. Record this truth table. What logic operation is this ?

---

12. Turn off power. You will now wire inverters onto the inputs of the existing circuit.

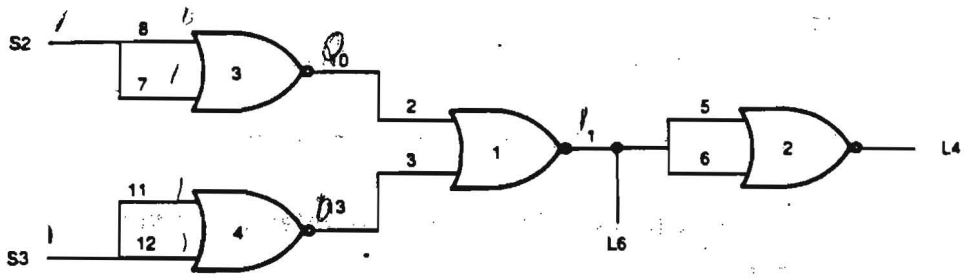
13. Remove the wire at S2 and connect it to pin 10.

14. Remove the wire at S3 and connect it to pin 13.

15. Connect S3 to pins 11 and 12.

16. Connect S2 to pins 8 and 9. The schematic for this circuit is shown in Figure 3-11.

FIGURE 3-11. Circuit Schematic.



17. Turn S1 and S2 OFF. Turn on power. Use S2, S3 and L4 to make a truth table for the circuit. Record your observations. What logic function is performed by this circuit ?

_____

18. Use S2, S3 and L6 to make a truth table for the circuit consisting of gates 4, 3 and 1. Record your observations here. Which logic function is implemented by this circuit ?

_____

19. Flip switches S2 and S3 ON and OFF together while watching L6 and L4 (output). Record your observations in the form of a truth table.

Questions

1. Which logic function is performed by the circuit observed in step 19? _____

2. All of the basic Boolean functions have been demonstrated using the 74LS02 quad two-input NOR gate. Design a circuit to implement the basic Boolean functions. Use the 74LS00 quad two-input NAND as your IC. Describe which gate combinations perform which Boolean functions. Breadboard your circuit and check it's operation.