74-Series Logic: Counter

Introduction

The 74-series logic family of integrated circuits was first introduced by Texas Instruments in the 1960's. It quickly gained popularity and became a de facto standard for the industry. These early components included individual logic gates, latches, flip-flops, and more complex functions. TI and other companies continued to add to the functionality over the succeeding decades.

The original 74-series chips used Transistor-Transistor Logic (TTL) technology. Succeeding generations introduced Complementary Metal Oxide Semiconductor (CMOS) technology, which offered lower power consumption.

As integrated circuit technology advanced, chips became larger and larger. Modern integrated circuits may include millions of logic gates, but the basic logic principles remain the same. In this class, you will use 74-series components to build increasingly complex circuits.

In this experiment, you will use a 74HC component to build a counter circuit that you will use as an input for future experiments in this lab.

Objective

- Introduction to 74-series TTL / HCMOS logic
- Create and test a 4-bit counter that you will use in future lab experiments

Equipment

- Breadboard (x1) and assorted wires
- DMM, Power Supply
- Pulse Generator (built in previous experiment)
- 74HC393 IC (x1)
- 220 ohm resistors (x4)
- LEDs (x4)

Procedure 1: Datasheets

Integrated circuits can get complex, even for the relatively simple functions that we are using in this lab. Datasheets are available from a number of manufacturers, and can be easily found online. Although the components are theoretically standardized, there may be differences in performance between parts purchased from different manufacturers.

Start by investigating the datasheet for the 74HC04, a basic chip that you may be using in future designs. In your lab notebook, answer the following questions.

1. What is the function of the 74HC04?
2. How many inputs and outputs does the 74HC04 have?
3. What is the maximum temperature at which the 74HC04 should be operated?
4. What supply voltage should be used for the 74HC04?

Procedure 2: Draw your Schematic

For this lab, you will be building a counter using the 74HC393. Find and download a datasheet for the 74HC393. The datasheet will have much more information than you need at this point, but it will serve as a reference.

Figure 1 shows the connections for the 74HC393.

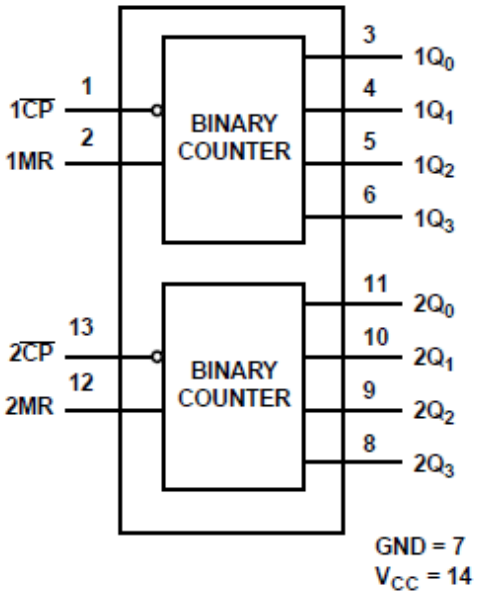

Figure 1: 74HC393 Connections

Note that in Figure 1, the pins are not placed according to their physical connection on the package. Remember that Pin 1 is located by the notch, and the remaining pins are numbered counter-clockwise (in this case, up to Pin 14).

In your lab notebook, draw a schematic showing how you will connect each of the pins for the counter.

- Your schematic should show the connections to the positive rail (Vcc, pin 14) and the negative rail (GND, pin 7). These are your power connections which allow the circuit to function.

- Notice that the 74HC393 has two counters. The first uses pins 1-6 and the second uses pins 8-13. You may use either one of them for your design. Think about how you will place your components on the breadboard when deciding which of the counters to use.

- CP is your clock input, and should be connected to the output of the pulse generator from the previous experiment.

- MR (Master Reset) is not used for this design. It should be connected to the negative rail (GND).

- Connect LED's to each of the outputs (Q0, Q1, Q2 and Q3). You may use whatever colors you like. Remember that each of the LED's must have a resistor connected in series as you did for the first experiment.

When you have completed your schematic, show it to the instructor for approval before moving forward with the breadboard build.

Procedure 3: Build Your Circuit

Before placing components on your breadboard, you should make sure that the power supply is not connected. You can do this easily by disconnecting the 9V battery.

Add the 74HC393 component to your breadboard. It should be alongside the pulse generator that you built in the first lab. You can see a suggested placement in Figure 2.

- Place the 74HC393 close to your previous circuit, but be careful that it does not connect to any rows that you have already used. That might create unintended connections.

- As before, be very careful placing the component. It is easy to bend the pins out of shape.

- Make sure that there is plenty of room to the right to add other chips for future experiments.

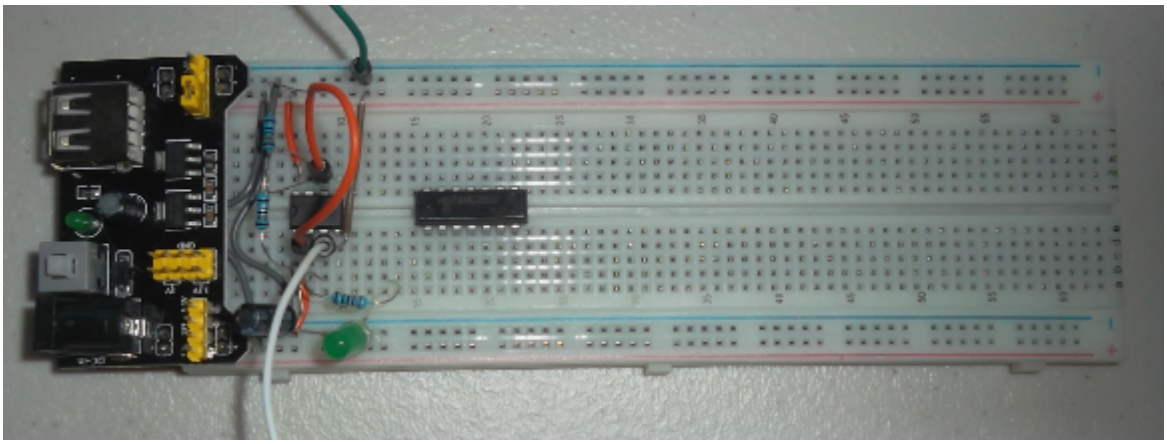

Figure 2: 74HC393 Placement

Now connect wires, resistors and LED's to complete the design in your schematic.

STOP: Have the lab instructor review your setup and circuit before you continue.

Connect the Power Supply

Connect the 9V battery to your circuit.

Are the LEDs turning on and off in a sequence? If so, congratulations! If not, your instructor will assist you in troubleshooting your circuit and setup.

Procedure 3: Test the Circuit

A) Record the sequence of the LEDs in your lab notebook.

B) Using a clock or a watch, estimate how long it takes the cycle to repeat.

C) Label each of the 4 LEDs with A, B, C, D (or Q0, Q1, Q2 and Q3 if you like). How long is each LED off and then on for?

Analysis:

A) How would you describe the pattern of LEDs in this lab? What could you do with these lights?

B) Complete the lab with a conclusion in your lab notebook. Record what you did, any problems you encountered and how you solved them. Also describe what you learned from this lab.

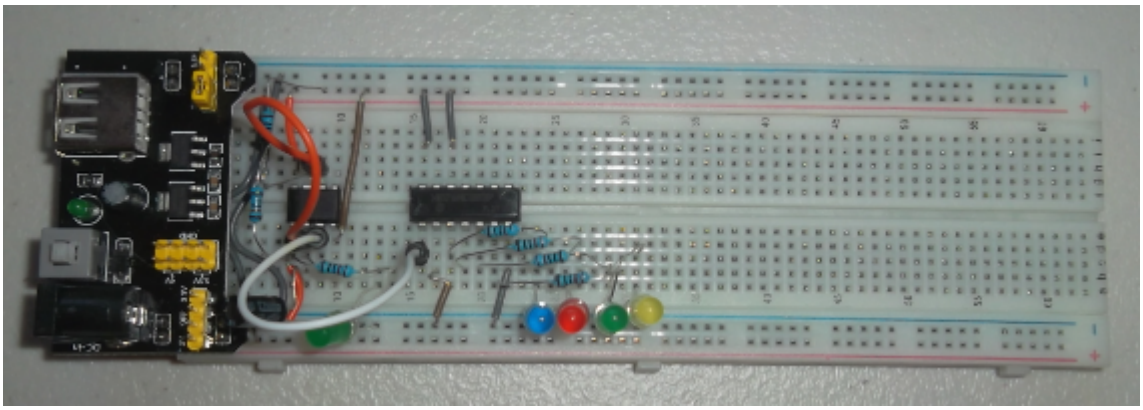

Figure 3: Sample Completed Circuit

(yours does not have to look exactly the same!)