Lab 6: Digital Logic
Introduction to Gates and Encoders

Objective:

This lab explores several simple devices and circuits. It includes the following

- 555 Timer Circuit
- Verification of truth tables for NAND, NOR, and XOR gates
- Exploration of TTL levels
- LED's
- BCD-7 segment decoders

Reading Assignments:

- Data sheet for 74LS00, 74LS02, 74LS47, and 74LS74 chips
- Data sheet for 7555 timer

PreLab Questions:

[PL1] Describe how the 555 timer chip works

[PL2] What is the maximum current that a 74LS00 NAND gate can sink?

[PL3] What is the maximum current that a 74LS00 NAND gate can source?

[PL4] Draw a schematic showing how to connect the 74LS47 "Seven-Segment LED Driver" chip to the LSD8164 7-segment LED Display. Show how the inputs are to be connected to "light-up" the number 4.

[PL5] Draw a schematic showing how resistors are connected in a SIP package, part # L101S102". What is the value of each resistor in this package?

[PL6] Draw a schematic showing how resistors are connected in a DIP package, part # "MDP1603102G". What is the value of each resistor in this package?

[PL7] What is the output at point F1 and F2 of Figure 3?

[PL8] Using the schematic of Figure 4, plot a curve of what the output at Y will be with an input range of 0-5V.

[PL9] When there are 3 possible switches that can be flipped, any combination of at least two would be a simple majority. Develop a logic table and logic gate system to determine a simple majority voting system. This can use any possible combination of logic gates (AND, OR, NOT, NAND, and NOR).

[PL10] Design a simple majority voting machine. This circuit needs to have 3 switches that can be turned on or off. With each switch you are casting a vote and changing the number of yeses and noes. Your circuit needs to turn on a green LED if you have a majority of yes votes being cast. If you do not have a majority, a red LED should be lit.

Lab Exercises:

A. 555 Square Wave Oscillator (30min estimated amount of time)

Wire up the circuit shown in Figure 1. Power the chip with +10VDC.

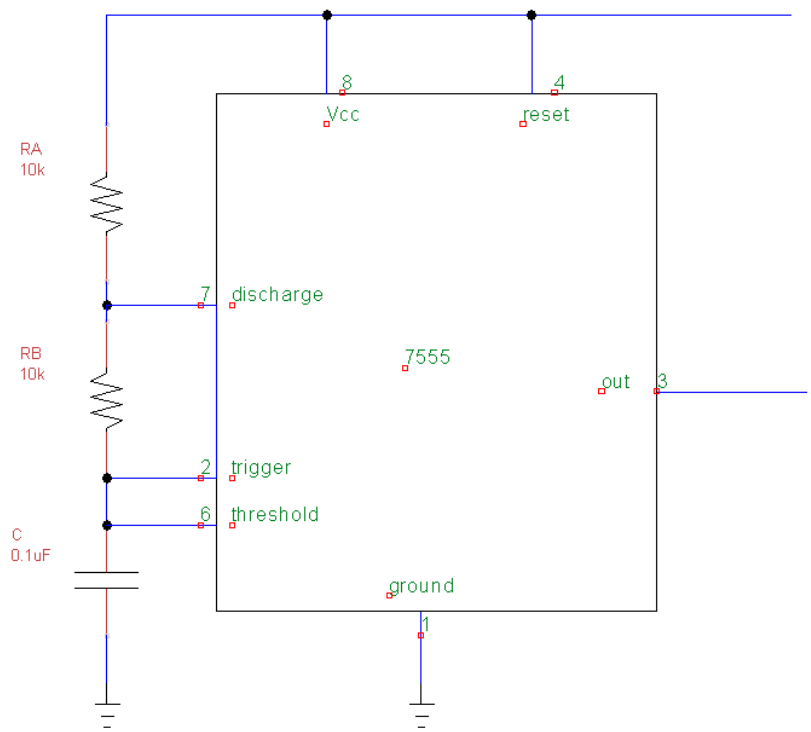

Figure 1. 555 Square Wave Oscillator

[L1] Sketch the output and compare its frequency with Equation 1.

$$f = \frac{1}{0.7 * C * [R_a + 2R_b]} \tag{1}$$

[L2] Look at the voltage across the capacitor and sketch it. What voltage levels does it run between?

[L3] Vary the supply voltage slightly, say between 8 and 12 V_{DC}. Does the output frequency change?

A trimpot is a resistor that can vary across two different values. The two resistor values are connected at each end and a center tap works as well. This then allows the user to vary what the resistance value between the two extremes.

Now replace R_a and R_b with a 20kΩ or higher trimpot. Wire the center tap to Pin 7 (discharge). Start with the potentiometer near the middle of its range (equal voltage division) and adjust it.

[L4] Does the output frequency change when adjusting the trimpot? Explain why it does or does not.

[L5] What is the range of output duty cycles (percentage) you are able to achieve by varying the trimpot?

[L6] At the two extremes of the duty cycle achieved by the trimpot, measure the resistance value across it.

[L7] At the 50% duty cycle value, measure the resistance value across it.

Finally, Place a diode between Pin 7 (discharge) and Pin 2 (trigger), oriented such that the diode is forward biased when the capacitor is charging. After you finish this section, **DO NOT BREAK DOWN** the 555 timer circuit. You will be using this timer chip as an oscillator for the remaining sections of this lab.

[L8] What is the range of output duty cycles with the diode present? Explain the reason for the observed change.

B. Floating (Unconnected) Inputs (15min estimated amount of time)

Verify with your TA that the logic gates you have chosen will work for the rest of the lab. Measure V_Y and infer the logic value of A.

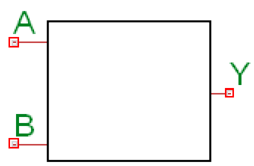

Figure 2. Floating Inputs Circuit

[L9] Is V_Y a logic high or low?

[L10] What is the logic value of a floating input? (Note: An unused input should never be left floating. Tie it to ground or to +5 V through a 1kΩ resistor.)

C. Basic logic circuits (15min estimated amount of time)

Verify the truth table for any two gates of your choice. These two gates will be used for the remainder of the lab. Verify with your TA that the logic gates you have chosen will work for the rest of the lab. Ensure that V_{cc} for both chips is +5 volts, and GND is grounded. Measure the output voltage at Y for all possible combinations of A and B. For A or B to be low, you must connect them to ground. Logic 1 is > 2 volts and Logic 0 is 0.8 volts or less.

[L11] Write a logic truth table based on your results for the two gates.

D. Constant/Timed Circuits (15min estimated amount of time)

Construct the two types of circuits that are shown in Figure 3 and verify its operation with your two gates of choice.

Figure 3. Circuit Setups

[L12] Experimentally measure and plot the waveforms at F1 and F2. Explain why your results are correct.

E. TTL Logic Highs and Lows (15min estimated amount of time)

Using the two gates of your choice, slowly vary the input voltage from 0 to + 5 volts, in steps of 0.1V (use the Agilent 3640 power supply). Measure the voltage at Y using the Agilent multimeter. Use your LabVIEW program to control and plot this circuit.

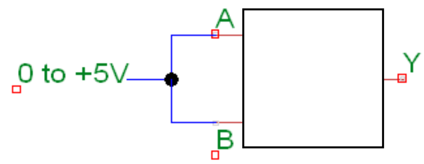

Figure 4. Voltage Schematic

[L13] Graph V_y vs. V_{input}.

[L14] What is the minimum V_{input} for which V_y > 2.4 volts?

[L15] What is the maximum V_{input} for which V_y < 0.4 volts?

F. High Output Source Current (15min estimated amount of time)

Use a single NAND gate for this section. Measure V_{out} as a function of I_{out} by varying R.

[L16] Plot V_{out} vs. I_{out}. (Try R=1MΩ, 10kΩ, 1kΩ, 470Ω, 220Ω and 100Ω.)

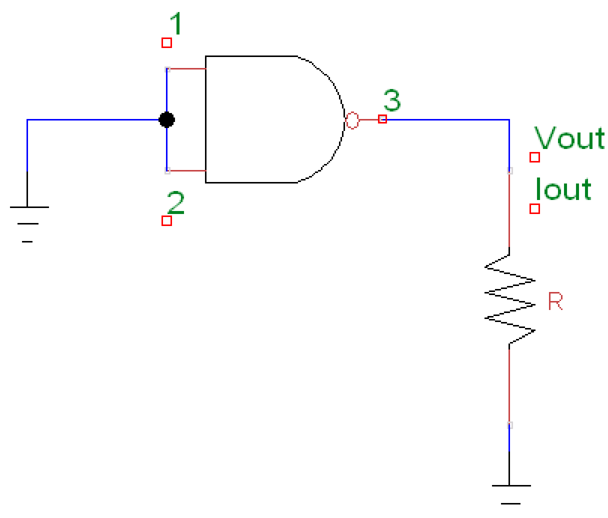

Figure 5. NAND and Resistor Schematic

[L17] What is the maximum I_{out} (source current) for which V_{out} >2.0V (valid TTL logic HI)?

G. Low Output Sink Current (30min estimated amount of time)

Use a single NAND gate for this section. Measure V_{out} as a function of I_s (sink current) by varying R.

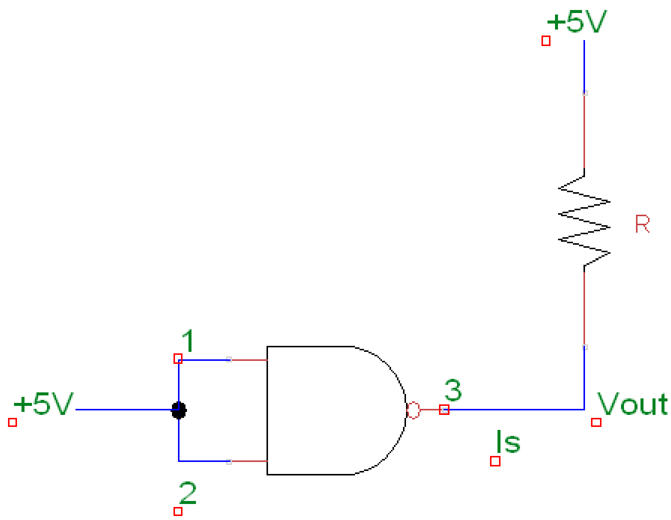

Figure 6. NAND Sink Current Schematic

[L18] Plot V_{out} vs. I_s. (Try R=1MΩ, 100kΩ, 10kΩ, 1kΩ, 470Ω, 220Ω and 100Ω.)

[L19] What is the maximum current I_s the output can sink and keep V_{out} <0.4V (valid TTL logic LO)?

H. The 7447 Seven-Segment LED Driver (30min estimated amount of time)

The circuit for a Seven-Segment LED is built for you. This schematic is shown in Figure 7. Look closely at the circuit diagram (proto-board). Notice what is going on with this circuit.

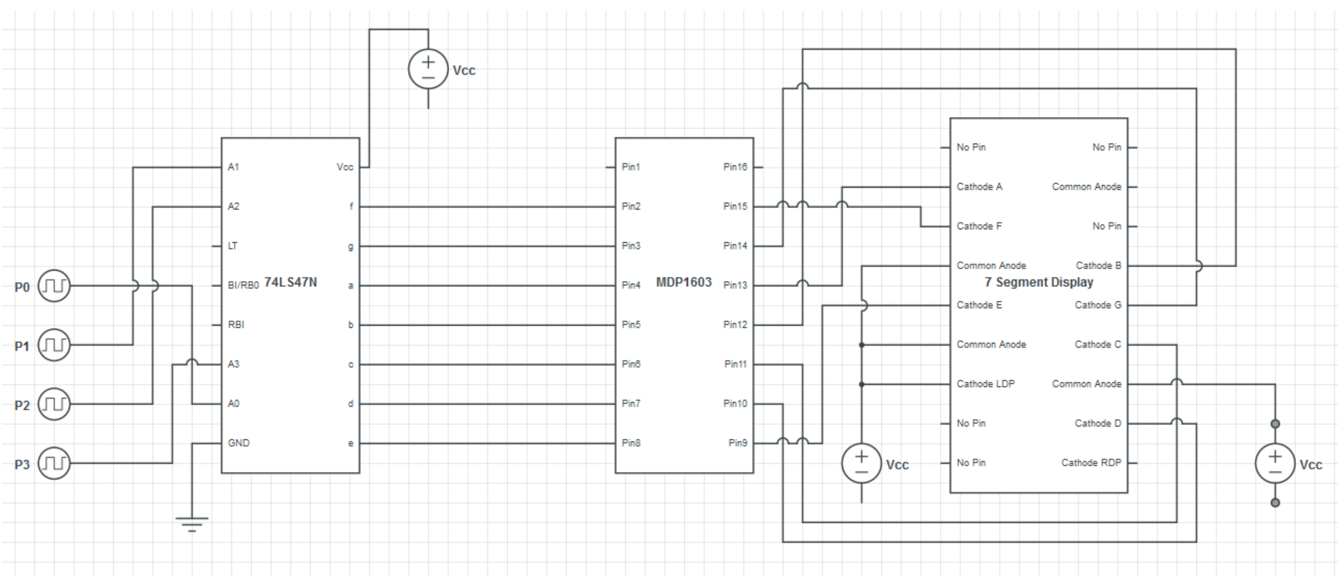

Figure 7. 7 Segment Display Schematic

[L20] What are the gray wires doing?

[L21] What is the role of the dip switches?

[L22] What are the blue wires, and why are they not linearly connected from dip switches to the 74LS47?

[L23] What are the dark green wires doing?

[L24] What do the 2 chips do?

[L25] What are the orange wires doing?

Connect the 7447 to a seven segment LED display and provide power and ground.

[L26] Input the following values for the ABCD inputs and record the 7 segment output.

- 0000
- 0101
- 1111
- 1000

I. Simple Majority Circuit (1hr estimated amount of time)

From the prelab question, you should have designed a circuit for a simple majority voting machine. You need to construct this circuit and prove that it works to your TA. Make sure to have a resistor in place as to not blow up your LED.

[L27] What is the truth table for this circuit?

[L28] Show a schematic for the circuit that you built and had working.