Lab 5 Prelab Assignment (Week 7, February 17 - 21)

Reading Assignment (Do the prelab and reading before the lab!):
Lab Book (Carley and Khosla) Chapter 11 (Flip-Flops)

Prelab Questions:
1. (1 point) Label and describe all the input and output ports of a D flip-flop and describe the state of output ports as a function of state of other ports (use a "truth" table)
2. (3 points) Carefully describe in a truth table how circuit 5.1 works. In particular, consider 3 cases: 1) When pts B and C = 0V (teach pendant not attached). 2) When C = 5V, B = 0V (teach pendant attached). 3) When both C and B = 5V (enter key depressed). For each case describe how the signals propagate and the outputs at A and E.
3. (1 point) Depict the voltage outputs as a function of time at points B, C, D, E and F of circuit 5.2 relative to a pulse input (0 to 5V) at A. Explain your answer.

Experiment 1: (Exercise 1, chapter 11) Testing the D Flip Flops
1) There are two flip-flops on the 4013 chip (see Fig 11.5 of Carley for pin diagram). Connect the two clock inputs together, the D inputs together, the set inputs together, and the reset inputs together. Simulate the data input by wiring the D input (Pin 5 and 9) to either logic 0 (ground) or logic 1 (5V). Connect the set and reset pins to ground. Connect the power pin (pin 14) of the 4013 chip to 5 V and pin 7 to ground.
2) Build four LED indicator circuits (as in lab 4, Fig. 4.1) and connect them to the Q, Q, D and clock input respectively.
3) Connect the function generator ground to circuit ground and the function generator signal (1-2 Hz square wave with amplitude between 0 and 5 V) to the clock inputs (Pins 3 and 11). Record Q and Q outputs (as the clock changes) as D is wired at first to logic 1 and then to 0.

![Fig. 4.1 LED circuit as a digital signal indicator](image-url)
Experiment 2: (Exercises 2-6, chapter 11) Testing the Enter Key Detector Circuit

4) Construct the circuit shown in Fig. 5.1 on the protoboard, using the pin diagrams (Fig. 11.5 and Fig. 10.6 of Carley). Simulate the teach pendant connections by leaving points B and C open (disconnected). Set up the function generator as in step 3 and use it as the clock input (for pins 3, 11, and 5 (4011)). Check output A using an LED signal indicator. Compare output A with prediction in prelab 2.

5) Connect point C (pin 13 of 4011 chip) to 5 V (to simulate the teach pendant being plugged into the robot); at the same time leave point B open (to simulate the case where the ENTER key is not activated). Provide your observation at output A and explain. Compare output A with prediction in prelab 2.

6) Next connect B to 5V (to simulate pressing the ENTER key). Explain what happens to A and compare with prelab 2.

7) Verify using the oscilloscope that point E is an inverted version of the clock signal only when teach pendant is disconnected (Point C open). Compare the result with Prelab 2 prediction.

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Fig. 5.1 Circuit for Enter Key Detector (The regular numbered pins are for the 4013 chip, the italics are for the 4011 chip)
**Experiment 3** (Exercises 7-9, Chapter 11) **Testing the Memory Chip Driver Circuit**

8) Construct the circuit shown in Fig. 5.2. Set the function generator at 55 Hz and examine the voltage waveforms at B, C, D and E with respect to voltage waveform at A, again using the oscilloscope (look at two at a time, e.g. B and A, etc.) Record the waveforms and compare with Prelab 3 predictions.

9) Connect the 55 Hz square wave to input A and examine the voltages at A and F simultaneously using both channels of the oscilloscope. Determine the time delay between the start of the pulses. Record the waveforms. Compare with Prelab 3 prediction.

10) Now use a single 1X probe for measurement at B, C, D and E. Make sure to adjust the oscilloscope to 1X also. Do you see any difference in the waveforms? Justify your observations. (Lab readers would be of assistance).

![Fig. 5.2 Memory Chip Driver Circuit](image)

**Experiment 4** (Exercise 10 of Chapter 11) **Installation of the circuits into the robot**

11) Install and test the above circuits into the robot following the exercise 10 of chapter 11.