Physics 335
Notes for Lab 2 – Flip Flops and Intro to Sequential Logic

March 10, 2009

Use only the fixed +5V outputs from the lab power supplies. As before, bring the volatges out to the strips on the breadboard and bypass the supply voltages with 0.1 μF capacitors. (Always do this as a matter of good practice—it makes the power source look like the low-impedance voltage source it should at all frequencies.)

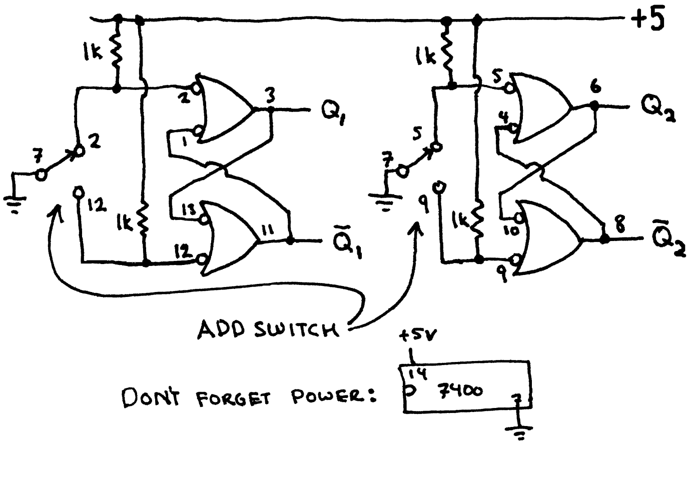
Be sure to connect all unused CMOS inputs to +5V or ground!

Lab manual sections **14-1, 14-2, 14-3, 14-4, 14-5**.

14-1. Build the latch circuit shown using the 74LS00 (TTL) so you don't need to worry about the unused inputs. Instead of using switches, just plug wires into +5 or ground at the inputs. Complete the truth table using the logic probe and determine which input combination determines the "memory" or bistable state.

For the rest of the lab we will need 2 "debounced" switches. There are partially wired switches available in the parts bins: a 74HC00 chip plugged into a socket and wired according to the diagram below. It is in a separate drawer of special parts marked "Debounced switch" (and other things). You need to hook up the power and plug the toggle switches into the appropriate points. The outputs of these will be used to reliably clock the flip-flop circuits.

PARTIALLY PRE-WIRED DEBOUNCED SWITCHES



After wiring up the debounced switches, confirm that the outputs go cleanly between HIGH and LOW as you flip the toggle switches. (You can confirm that the input switches actually bounce if you trigger the 'scope on the output of the debouncing circuit while watching one of the inputs to the latch circuit. You will need a pretty high sweep rate on the scope to see the "trash" on the input.)

14-2. Use a 74HC74 chip (CMOS), and remember to wire the unused inputs to ground or +5 (it doesn't matter which). The inputs are the $\overline{S}$, $\overline{R}$ D *and* clock (▷) lines (pins 1, 4, 10, 11, 12, 13; see the pinout sheet in the lab).

a) Set up one of the flops for testing (there are two per package) with one debounced switch wired into the D input and the other hooked to the clock input. Confirm the following truth table:

$\overline{S}$	$\overline{R}$	clock	D	Q
H	H	↑	H	H
H	H	↑	L	L
H	H	↓	X	unch.
L	H	X	X	H
H	L	X	X	L
L	L	X	X	?

Note: the text uses both an asterisk (*) and a prime (′) to denote inversion: $\overline{S} \equiv S^* \equiv S'$.

b) Wire up the circuit as shown in L14.3 (you only need to add one wire) and clock the flop manually with the debounced switch. Count how many times you need to flip the switch for Q to change.

Remove the manual clock connection and clock the flop with the TTL output of the function generator. Watch both the clock and Q lines on the 'scope and draw the two waveforms you see.

To see the propagation delay, you will need to increase the sweep rate and generator frequency. Make sure to trigger on the clock input only. Compare what you get for propagation delay to the specifications for the part. A spec sheet is given in the manual, pp. 595-6.

14-3. Wire up the 74HC112 and discover the truth table. Note that "Q_{n+1}" means the state of the output Q following clock edge n.

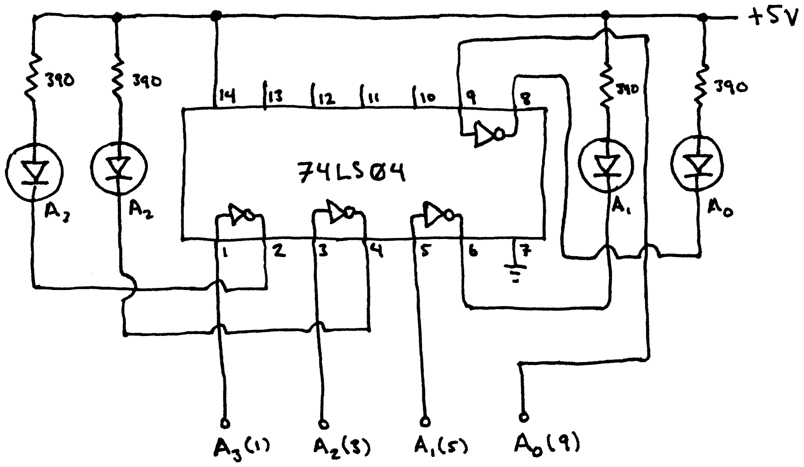
Note: be sure to wire the $\overline{S}$ and $\overline{R}$ inputs of both flops in the package to high. See the pinout diagram on p. 609 ("CLR" is the same as $\overline{R}$).

You do not need to wire up the circuits shown in part (b), but deduce their truth tables from the basic truth table.

The possible types that types "A" and "B" flops can be are either "D" (as in 14-2) and "toggle" or "T". Show their truth tables.

14-4. (A) Wire the two *J-K* flops as shown, and connect two inputs of the LED array (properly powered with +5 volts) to the Q_0 and Q_1 outputs. Connect the clock input to the TTL output on the function generator, and look first at the behavior of the LED lighting when the frequency is set at about 1 Hz (or a bit higher).

PRE-WIRED FOUR LED ARRAY



Clock the counter at high frequency and look at the outputs on the 'scope. Draw comparative waveforms. Finally, crank the frequency up until you can see the effect of propagation delay on the two waveforms.

(B) Make the small change to turn the counter into a synchronous type, and compare the high frequency waveform with what you saw with the ripple counter.

14-5. You already did most of this. Just wire the switch directly as shown in L14.10, and compare with what you see when the clock is connected through the debouncer. *Note: our little SPTD switches are not as "bouncy" as the microswitches described in the manual; you may need to flip the toggle vigorously to make it bounce.*