Physics 314, fall 2016
Lab 4: Counters, shift registers, one-shots

1. Synchronous vs. ripple counters

Build a divide-by-four ripple counter using J-K flip flops (SN7476). Drive LEDs with the Q_A and Q_B outputs. First, clock by hand using the debounced pushbutton and verify the "divide-by-four" counter behavior.

Next, we're going to look for the delay due to the ripple. For this, we need to use the HP function generators at frequencies > MHz, since we expect the delay to be on the order of tens of ns (see datasheet for the 7476). First, use the oscilloscope to set up the function generator to put out a TTL signal: a square wave between 0 and 5 V. Hint: you'll have to adjust the offset as well as the amplitude of the square wave. When you're happy with that, use the HP function generator to clock your circuit. On the oscilloscope, look at the clock along with first Q_A, and then Q_B. Then look at Q_A and Q_B on the scope. Measure the "ripple" delay effect as carefully as you can. (If your signals look messy, it's probably due to reflections at the junction between the high-Z scope and the 50 Ω cable. Use a terminator to eliminate the reflections.)

Now alter the circuit to make it synchronous. Use the scope to confirm that the delay you saw with the ripple version is gone.

2. IC counter

The SN74LS193 is a synchronous 4-bit up/down counter. From the attached datasheet, figure out how to hook it up to make it do the following:
a) Count up from 0 to 16 (15+carry bit)
b) Count down from 15 to –1 (0-borrow bit)
c) Demonstrate the clear, load, and count sequence shown in the datasheet.

Sketch your circuit diagrams and record the sequence of inputs needed to make the counter do each of these things.

3. Shift register

Build a circuit like the one in Fig. L14.12 of Hayes & Horowitz. (NB: their FFs are a little different from ours—the pinouts are different, and we need to hold two pins high on each chip to make the FF behave as we want it to.)

Drive LEDs with all four Q outputs. Use one of the debounced pushbutton switches as the clock. Use a manual switch to set IN as high before the first clock pulse, then set it low. What happens on each clock pulse?

Explain how the shift register works.

Describe what you have to do to load the shift register with the binary value 1011 (reading across from Q_A to Q_D).

4. Double-barreled one-shot

Modify your previous circuit with a couple of NAND gates to create the circuit in Fig. L14.13 of Hayes & Horowitz. Look at OUT A and OUT B with the LEDs.

Use a manual switch to drive Trig and use the TTL output of the function generator to drive the clock at a low frequency (a few Hz). Watch the outputs. Take Trig low for a second or two, then high. You should see first one LED go low, then the other.

Explain how this one-shot works.