**Physics 48** 01X

# Lab #11 – Digital Circuits II

The purposes of this lab are

- to learn what a shift register is and how to construct one from flip-flops
- to learn what a counter is and how to use it to construct a divide-by-N circuit
- to become familiar with the 555-timer (one-shot) and to build an oscillator with it (only one of its many uses).

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| Equipment at each station: | Centrally available: |
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| digital oscilloscope | wire and wire cutters/stripper |
| 2 multimeters, 2 power supplies | red and black banana plug cables |
| signal generator, standard breadboard | assorted resistors and capacitors |
| CMOS digital ICs: (4040 counter, | HP 3325 signal generator (up to 20 MHz) |
| 4081 quad AND, 4013 dual flip-flop, | bags of LEDs |
| 555 monostable multivibrator) | |

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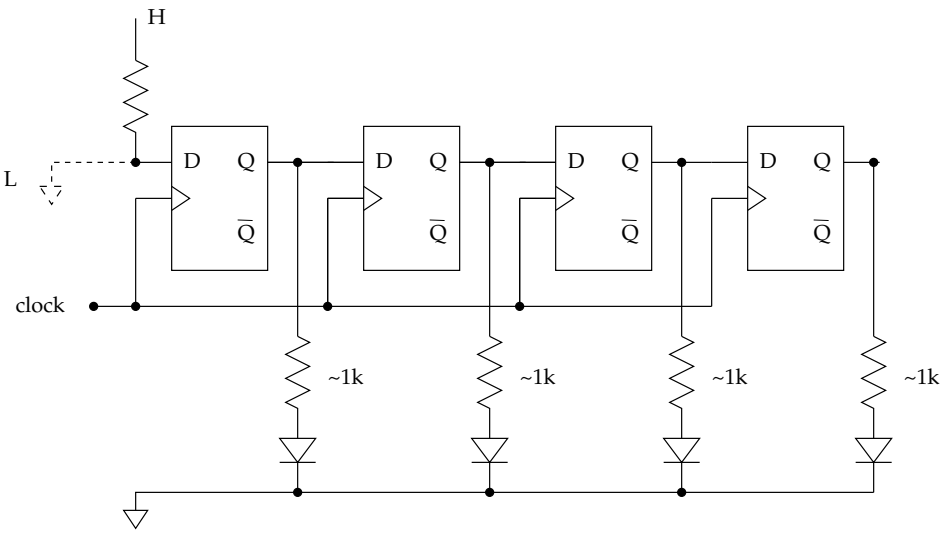
## 1. Shift Register from Flip-Flops

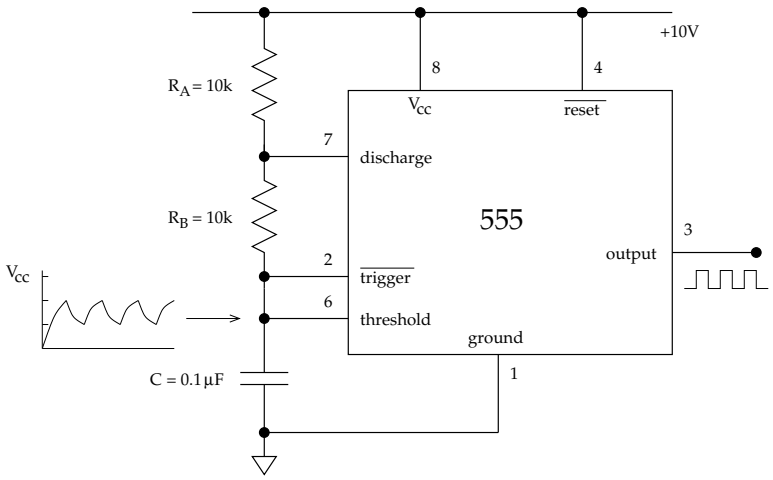



- Using two dual 4013 D flip-flops, build a 4-bit shift register as shown above. Include the LEDs and current limiting resistors on each output for visual confirmation of the *state* of your register. It may be neccessary to increase the power supply voltage $V_{DD}$ above 5V to drive the LEDs.
- Tie the input of your shift register to *high* through a "pull-up" resistor and attach a wire to the input so you can easily change the value of the input.
- Clock the shift register at some suitably low speed (~1 Hz) so that you can watch it in action. Apply a sequence of changing bits at the input and watch them move through the register.
- Optional: Connect all your shift registers together to make a giant register that can handle a larger *word*.
- Optional: Tie the output of the register to the input, making a circular register. How could you *load* this type of register?

## 2. Divide-by-N Counter

- Examine your 4040 12-bit ripple counter and it's data sheet. Thankfully you can buy such a device and not have to build it from individual flip-flops! Connect $V_{DD}$ to +5V and $V_{SS}$ to ground. Connect a $5V_pp$ square wave through an AC coupling capacitor. Unused inputs (e.g., reset) should be grounded.
- Verify that the outputs divide by $2^N$. Monitor a few of them on your scope, or better yet, rig up some LEDs.
- Disconnect the *reset* and wave your hand around the IC. Note what happens and why unused CMOS inputs should be grounded.
- Using your scope, measure the delay for several different outputs, noting that the delay increases for progressively higher outputs. Increase the power supply voltage $V_{DD}$ to 15V and note how the delay changes.
- Construct a "÷ 5" counter by feeding the appropriate outputs to an AND gate and into the reset.
- Optional: Connect our counter to your neighbors to make a 24-bit ripple counter.

## 3. Monostable Multivibrator




- Construct an oscillator for your counter using the 555 timer (a.k.a. "one-shot"). The figure above shows one way to make this circuit, including the pin numbers. An explanation of how this circuit works is given in the accompanying 555 data sheet.
- Examine the output before you put it into your counter.
- Optional: filter the output to remove the higher harmonics and produce something more like a sine wave.
- Optional: Use a trimpot to make the output frequency variable.

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