# LABORATORY 8

PHYSICS 117, Winter 2017

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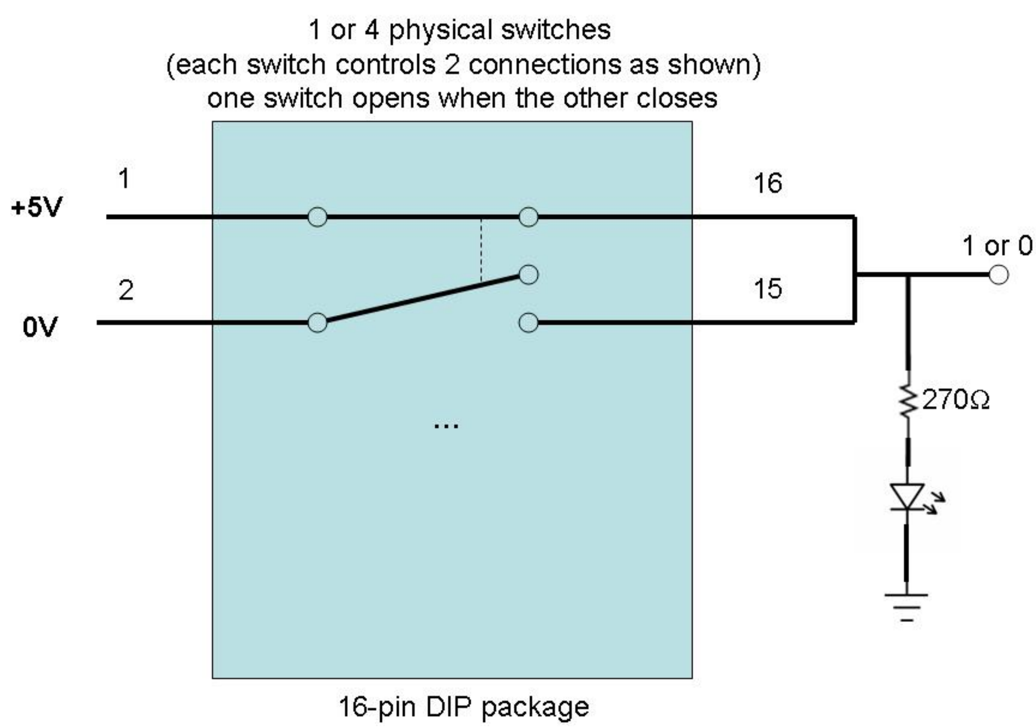
<u>On/off logic switch with LED</u>

It is going to be helpful for you as we study more digital circuits to have switches that switch between +5V and 0V so you don't have to move wires--or forget to connect all CMOS inputs to 0 or 5V. Also an LED is handy to have to indicate the "on" at state (logic=1) (+5V). We want to use an SPDT switch.

Nominally, the SPDT switch needs 3 connections to the outside world. However, the manufacturer has decided to give you more flexibility by having two switches with opposite on/off states as shown below in a DIP package. By connecting pins 15&16 (or 13&14, 11&12, 9&10) you turn each switch into a standard SPDT as shown below.

a) Set up two bits you can control with an SPDT switch. Each should have their own LED showing 1 (on) or 0 (off). Do this on the side of your breadboard away from other work you will do later since you will use it multiple times.




This switch is the blue package. There is another in a red package that works differently but you can figure it out!

b) Using the scope trigger, try to catch the rattiness of the switch transition on its up and down transition. You may find this is worse with the red package switch than the blue. Repeat this with a 1 and/or 15 uF capacitor on the "pole" side of the switch and see if it is better (It should be). See which value works best.

<u>NANDs--> other gates</u>

c)

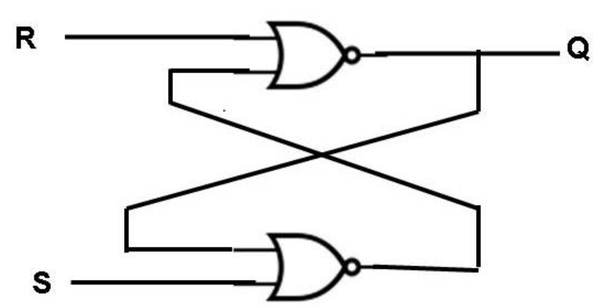
1) Use NAND gates to light an LED only when two inputs are high (i.e., make an "AND")
2) Use NAND gates to light an LED when either of two inputs are high (i.e., make an "OR")
3) Use NAND gates to light an LED when either but not both of two inputs are high (i.e., make an "XOR"). This can easily be done with 5 gates and a challenge to do with 4.

<u>Various off-the-shelf Gates</u>

d) Find the CMOS-family XOR, and AND chip in the trays that do these logics directly. Confirm that they work as advertised by measuring their truth tables using your switches and putting an LED on the output. (Remember to hook up unused inputs to 0 or +5V) Feel free to do others.

<u>S-R Latch</u>

e) Build this crazy-looking circuit below with the 74HCT02 (Dual NOR). The crossing lines are not a connection.




f) Experiment with the input states S and R using your switches with Q driving an LED. Why are called "S" and "R"? Which input state is the "memory" state. (Hint: The S=1, R=1 state is unused and not important. ) This circuit is called an S-R Latch

<u>D-type Flip-Flop</u>

g) Take a 74HCT74 dual D-type flip-flop from the drawers for this section and look up its data sheet. Take control of one of the D (pin 2) and CLOCK (pin 3) with your two switches and have Q drive an LED You can put "Reset*" (pin 1) and "Set*" (pin 4) to 1

(+5V) and ignore them for now. Remember that the four unused inputs on the chip should be set to 0 or +5V.

--Confirm that the flip-flop ignores changes at D if there is no clock transition.
--Confirm that the flip-flop moves D to Q if there is a rising edge of the clock

h) Confirm that your Flip-flop only changes Q when the clock is rising, not falling. You will likely find that it fails and reacts on a falling edge. That is due to "switch bounce". Try instead using a 1 uF capacitor as you did in part b.

i) When Q is on, connect RESET* to 0V and see what happens. Try to make the output change by using D and CLOCK. When you see what RESET* does, play around with SET* as well to verify that it does what it sounds like.

"Seven Segment" Display
j) Take a seven-segment common-cathode numeric display (LDS-C514RI) from the drawer and look up its datasheet. Notice that it is just 7 diodes connected in parallel to a common cathode. Connect the common cathode to GROUND (but through a 270Ω resistor in series so you don't blow it out!!) This current-limited power connects to pin 3 or 8. Light the various segments by connecting pins 1,2,4,5,6, or 7,9 or 10 to +5V either singly or in combination. (REITERATE: Do not hook directly to GROUND, have at least a 100Ω resistor in series.)

Divide-by-10 and Counter
k) Use the CD4026 decade counter as a divide-by-10. You need to hook up some extra pins that you can find on the data sheet. Fill in the pin numbers and for the enable/inhibit/reset pins figure out whether to hook up to +5 or 0 V.

Pin _____ = +5V power,
Pin _____= ground power,
Pin _____= clock input (square wave from your generator)
Pin _____= output (i.e., one pulse per 10 inputs)
Pin _____= ______ Volts in order to enable the display (for use below)
Pin _____ = ______ Volts "clock inhibit"
Pin _____ = ______ Volts "reset"

Use your square wave generator as the input clock. Remember to set the offset so it is changing between 0 and +5V. Use the scope to show it gives an output pulse for every 10 input pulses.

l) Hook up the CD4026 chip's drivers to the 7-segment common-cathode LED numeric display (LDS-C514RI) and clock the chip at 1 Hz using your function generator. (Remember you need an offset to swing between 0 and 5V.) You should see the display count properly. You can also make it count faster than you can see it change, but catch it on your phone's Slo-Mo mode if you have one.