LABORATORY 5

PHYSICS 117 (Winter 2017)
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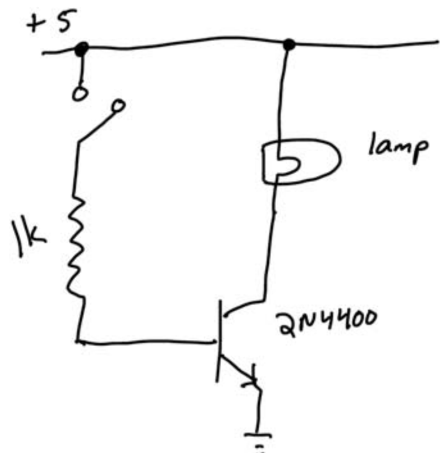
Reading: Sherz & Monk: sections 4.3, 8.1-8.5, 8.8

a) Transistor Switch

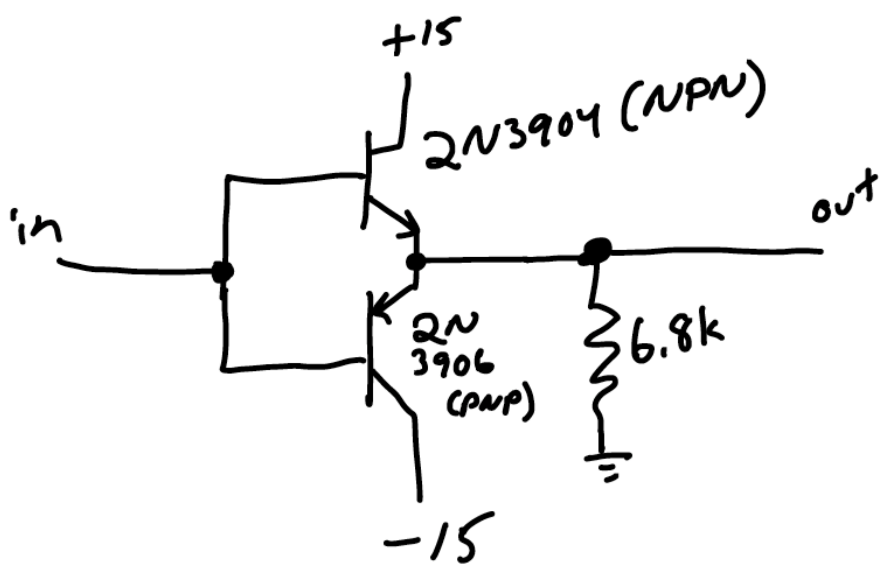
The circuit below uses the transistor in a mode called "saturation", where it provides as much current as it can so there is no longer a linear relationship between I_B and I_C. Or you can consider it as β dropping as I_C increases. We are using a 2N4400 now which is just like the 2N3904 but can drive more current and dissipate more pwer. Build the circuit below.



What is the minimum β that still lights the lamp? When the switch is "on" how much power does the transistor dissipate?

b) Push-Pull

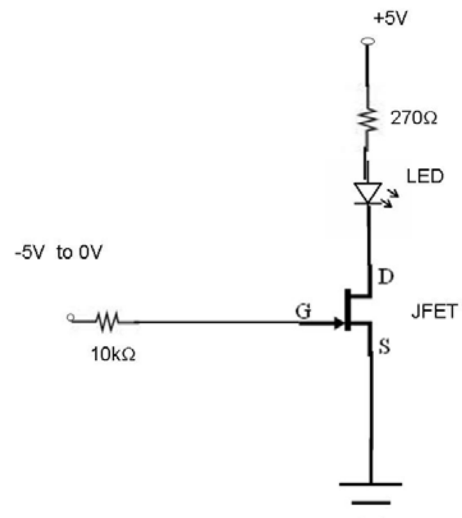
Build this circuit:



Drive it with a sine wave of a few volts amplitude. Note that the output does not look as good as the output of the single transistor circuit you built last week. Why not? (This is called a "Class B" amplifier and your amplifier last week was "Class A". Do some research to find out the difference. What are the advantages and disadvantages of each?)

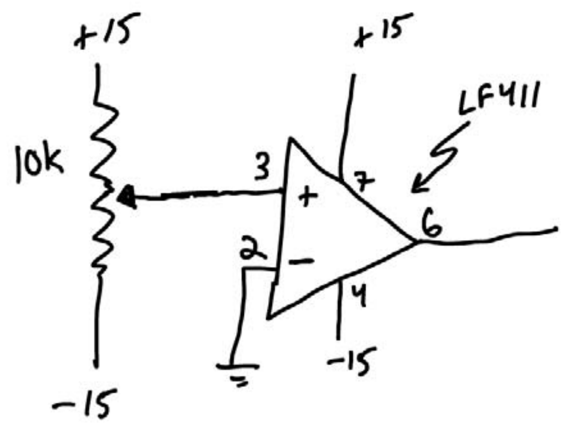
Try adjusting the DC offset of your signal generator and see what happens.

c) <u>Field-Effect Transistors (FET)</u>
Build a switch using a FET transistor (J309, J310 or 2N4392 in our lab, which are N-channel JFETs) transistor using the circuit below. (Look up the pin assignments!)



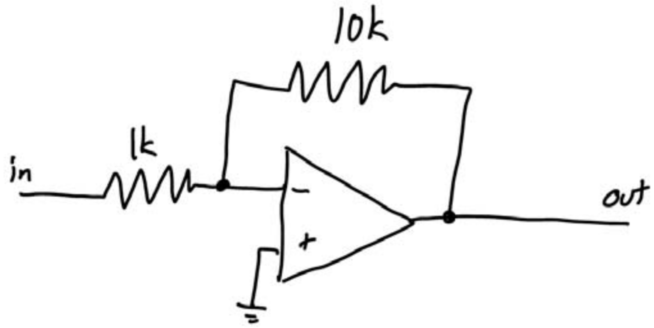
Connect the 10kΩ resistor to -5V versus 0V to show how the JFET works as a switch. Why do you need the 270Ω resistor? Now instead of connecting the 10kΩ resistor to -5V, instead touch one finger to your -5V supply a finger on the other hand to the gate. (Use only external unbroken skin.) What does this say about the input impedance of a FET? You can vary the gate voltage from -5 to 0 Volts and see when it switches. Try disconnecting the 10kΩ resistor from the power supply when the LED is on and watch the behavior of the circuit as you move your hands and dance around.

d) “Open Loop” Op-Amp test
Use a potentiometer as shown below to try to make the Op-Amp output a value somewhere between the two rail voltages:



Hint: You can monitor the input and output voltages on your scope using AUTO trigger.
Note: We have special “chip pullers” to remove your chip from the breadboard without breaking pins.

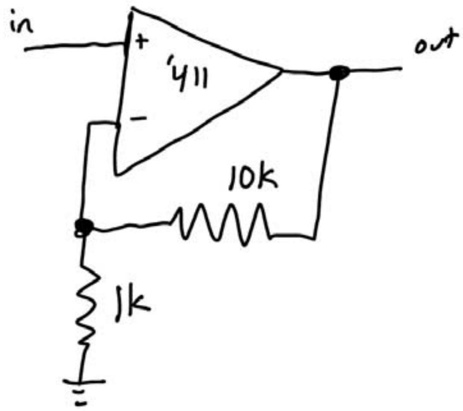
e) Op-Amp amplifier
Construct the inverting amplifier below with +5V and –5V rails.



Drive it with a 1 kHz sine wave and measure the gain. What is the maxiumum output voltage swing? How good is the linearity? (Hint: put in a triangle wave). Try sine waves of increasing frequencies. Note that at some fairly high frequency it starts to fail. Try a similar frequency square wave and see what happens. You are seeing the effect of “slewing” and you can measure the “slew rate” using the square wave input. (HINT: It helps if you use a fairly large amplitude to get a good measurement.)

Measure the input impedance of this circuit (including the resisitors) using another 1kΩ resistor. Try to measure the output impedance (but you will fail) as long as you are not drawing much current from the output (it maxes out at around 20 mA).

f) Non-inverting amplifier   Construct the circuit below. Don't forget the rails.



Confirm the voltage gain is what you expect.   Try to measure the input impedance (you will fail).   You might actually find some effect around 1MΩ but that is actually due to the capacitance of the input and your probe or wires.

g) Bandwidth

Measure f_{3dB} of your amplifier (either one that you built). It is not caused by RC but the speed of the electronics inside the op-amp. The range of frequencies any device works for (in this case from 0 Hz to ν_{3dB}) is called the "bandwidth" of the amplifier.   Compare this bandwidth to an older model (but famous) op-amp we have in the drawers, the LM741.