Lab 6

In [1]:
```
%matplotlib notebook
import numpy as np
import matplotlib.pyplot as plt
from IPython.display import Image
from decimal import Decimal
from math import pi
```

In [2]:
```
Image("Equipment.png")
```

Out[2]:

Equipment

- Analog Discovery 2
- Laptop with WaveForms installed
- Breadboard adaptor
- Large breadboard
- Components
  - Transistors: 2N3906, 2N3904, TIP32CG, TIP31CG
  - Resistors: A whole bunch of different values
  - Capacitors: 2x 10 μF
  - Jumper wires

In [3]:
```
Image("Part1.png")
```

Out[3]:

Part 1 – Identifying transistors

First we will do the transistor junction test from last week's homework. Select two transistors from the list in the Equipment section. Do **not** look up their data sheets yet.

For both of the transistors you selected, label the terminals "1," "2," and "3." Using the diode test function of your DMM, complete a table like in problem 3b from homework 7. Using that table, determine the type (npn or pnp) and pinout (which pin is which) for each transistor.

Once you have come up with your answer, check it by looking up the data sheet.

Transistors pulled were 2N3904 and 2N3906

2N3904 is a NPN resistor

Emitter is 718mV collector is 721mV

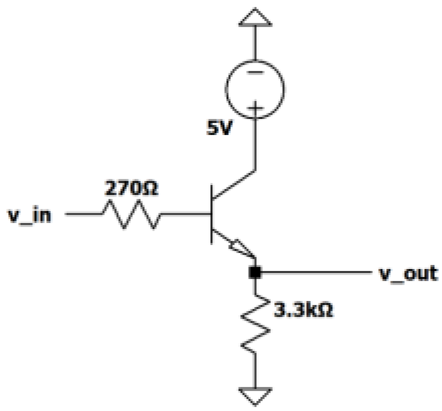
2N3906 is a PNP resistor

Emitter is 712mV collector is 706mV

In [4]:
```
Image("Part2.png")
```

Out[4]:

Part 2 – Emitter follower



Build the emitter follower circuit shown on the left, using transistor 2N3904. When connecting the transistor, pay close attention to the pinout from the data sheet. I recommend making a small sketch and placing it right on your breadboard to help you keep the pins straight.

Drive v_in with a sine wave of amplitude 3 V. Does v_out look like you predicted in the homework?

Next connect the bottom of the 3.3 kΩ resistor to -5 V from the V- power supply. Does the output match your prediction from the homework?

We created a circuit with amplification of 1. Can you think of any reason you might want this circuit, instead of just using v_in directly?

My Z Impedance is 8.42k Ohms

I did not finish that question in the homework because I had no clue what I was doing but hey I worked the problem backwads and dropped my pot to 270 and yes I was getting half the total Voltage amplitude. But this one did not cut out the underneath and it was a flat top. It looked like the jumping voltage I had before is the top of the voltage that was cutoff. If that dosn't make sense to you Oh well.

Maybe you ahve a low source and need to amplify with what you have. Or maybe you have critical components proir to this and now you gotta beef that boy up.

In [5]:
```
Image("Input_Z.png")
```

Out[5]:

Measure input impedance

The base of the transistor draws a small current. We can determine the input impedance by swapping out the base resistor with progressively larger resistors until we see an attenuation from v_in to the base of about 50%. When the attenuation is 50%, we can reasonably conclude that the input impedance is equal to that of the resistor (via the voltage divider equation).

Return the bottom of the 3.3 kΩ resistor to ground.

Start with a 33 kΩ resistor instead of the 270 Ω at the base. How much attenuation do you see? Try larger resistors until you get 50% attenuation. You may want to try using a 100 kΩ pot (or more) instead – vary the resistance until you get the desired attenuation, then measure the resistance after the fact.

Using the relation, $Z_{\text{in}} = (\beta + 1)Z_{\text{emitter}}$, estimate β.

In [19]:
```
Z_in = 8420
Z_E = 54.6
Beta = (Z_in/Z_E)-1
print("{:.0F}".format(Decimal(Beta)))
```

```
153
```

In [8]:
```
Image("Output_Z.png")
```

Out[8]:

Measure output impedance

Return the 270 Ω resistor at the base. Measure the peak of the output voltage. This is the "open circuit" voltage for the Thevenin circuit.

Attach a 1 kΩ "load" from the output to ground. Measure the change in the output voltage.

Using the Thevenin model, you can consider the 1 kΩ load the lower resistor in a voltage divider, where the upper resistor is the Thevenin impedance, ie the output impedance of the emitter follower. Calculate the output impedance.

In [18]:

```
V_out = 1.282
V_in = 1.352
R = 1000

Z = ((V_in*R)/(V_out))-R
Z
```

Out[18]:

```
54.60218408736341
```

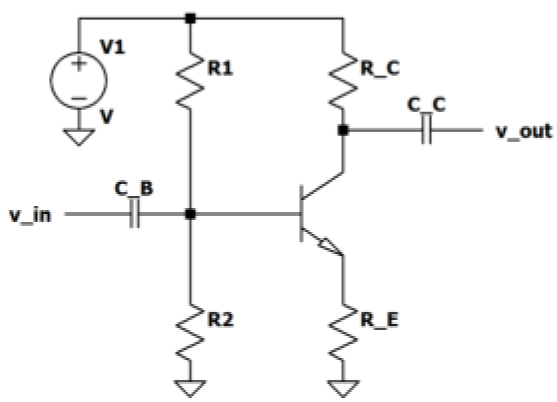
In [9]:

```
Image("Part3.png")
```

Out[9]:

Part 3 – Common emitter amplifier (optional)

Build the common emitter amplifier we explored in the homework, using transistor 2N3904:



Use the following values:
$V_1 = 5$ V, $R_1 = 20$ kΩ, $R_2 = 10$ kΩ, $R_E = 1$ kΩ, and $R_C = 5$ kΩ, and 10 µF capacitors.
(Note V1 is different from the homework due to our kit limitations, but you can grab a real power supply if you want.)

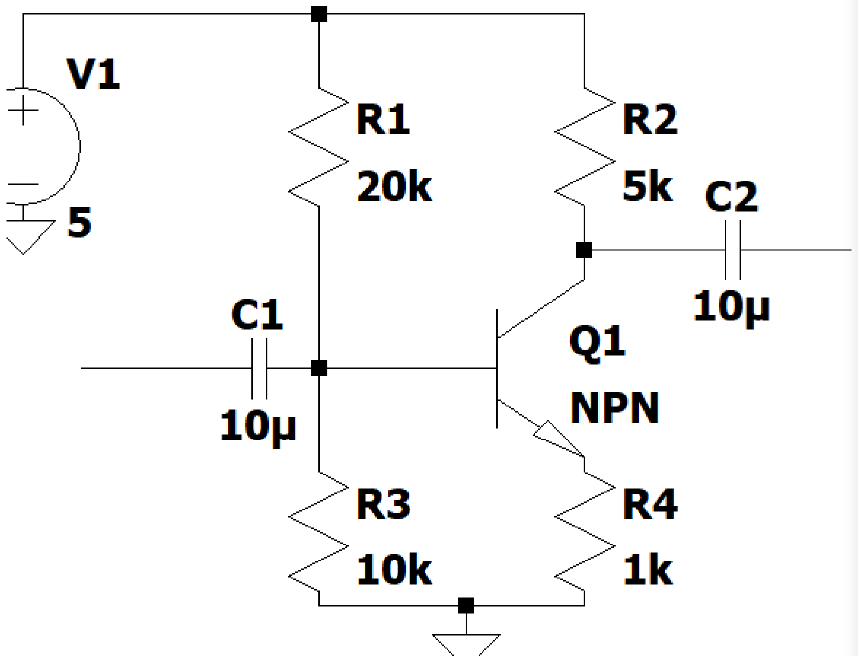
Measure the DC operating point (voltages at emitter, collector, and base) and the amplification of the circuit.

Check your measurements using LTSpice (or similar).

In [2]:

```
Image("1.png")
```

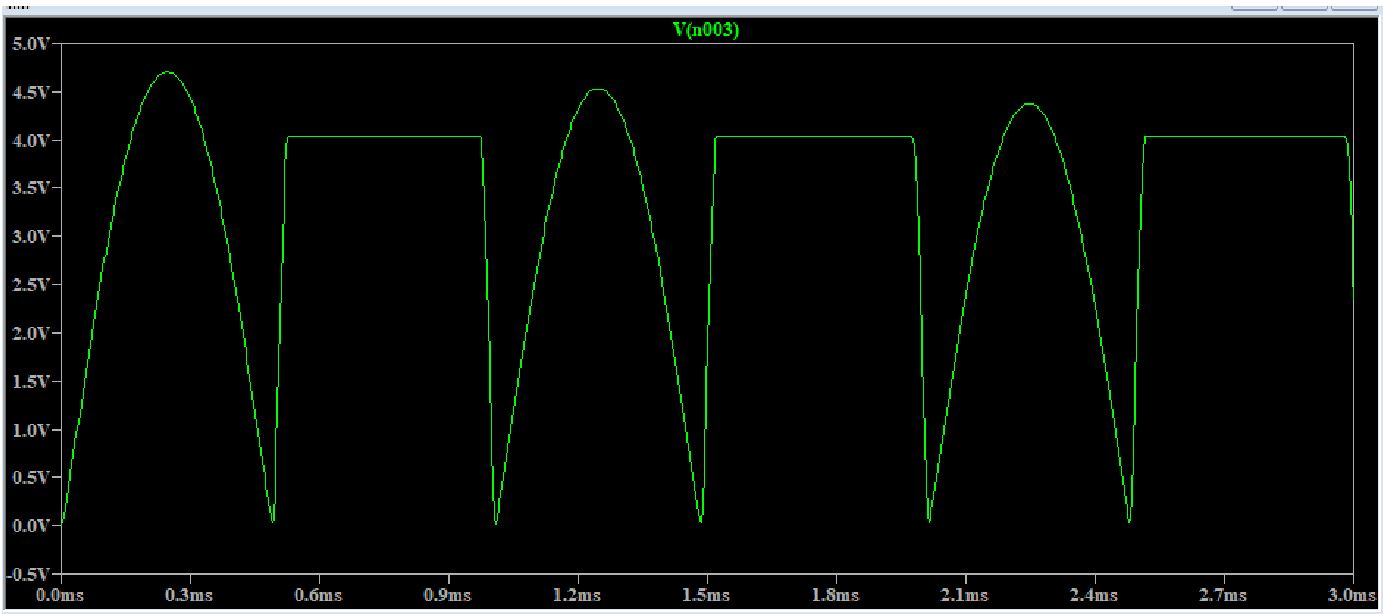
Out[2]:

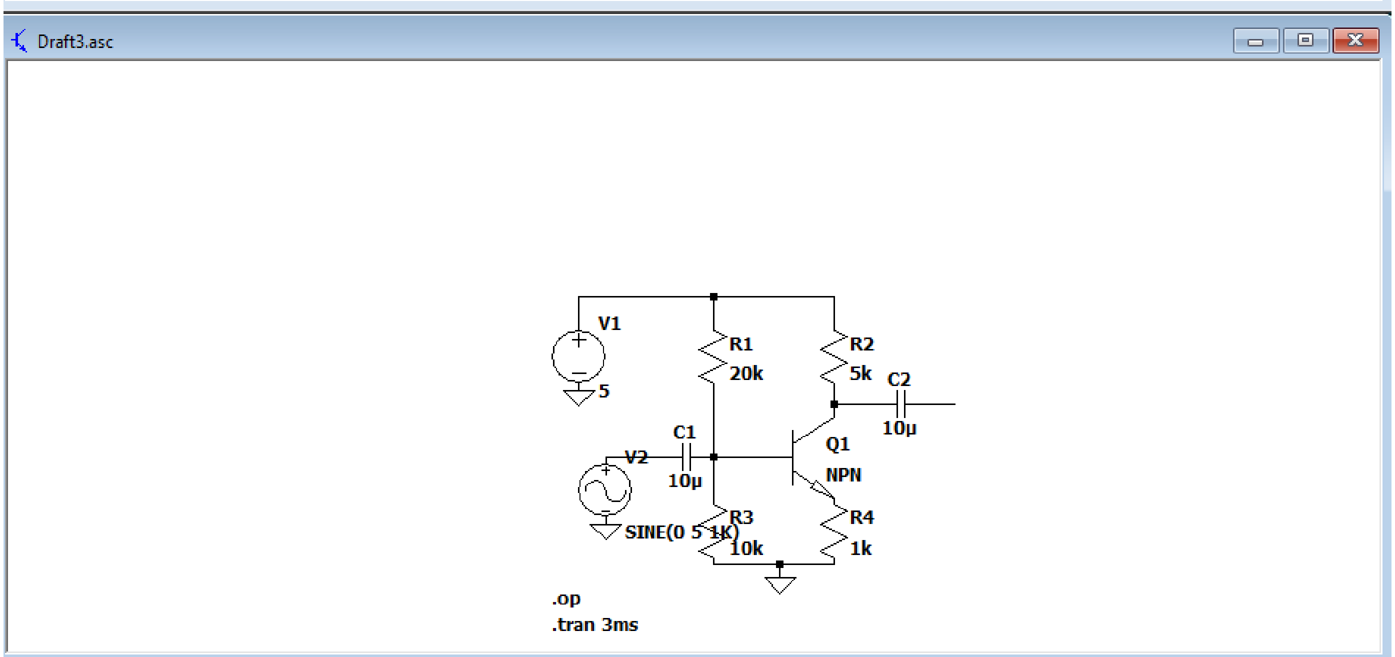


V(n001):	5	voltage
V(n005):	1.58861	voltage
V(n002):	0.960218	voltage
V(p001):	0.819665	voltage
V(n004):	1.58859e-05	voltage
V(n003):	9.60208e-06	voltage
Ic(Q1):	0.000807979	device_current
Ib(Q1):	1.1709e-05	device_current
Ie(Q1):	-0.000819687	device_current
I(C1):	1.58859e-17	device_current
I(C2):	-9.60208e-18	device_current
I(R1):	0.00017057	device_current
I(R2):	0.000807956	device_current
I(R3):	0.000158861	device_current
I(R4):	0.000819665	device_current
I(V1):	-0.000978526	device_current

In [3]:
```
Image("2.png")
```

Out[3]:





In [10]:
```
Image("report.png")
```

Out[10]:

Shortened lab report

Submit a ~1 page report demonstrating you did the lab. Be sure to include the following items:

- Part 1
  - Which transistors did you test?
  - Your diode test table
  - The type and pinout you determined for each transistor
- Part 2
  - A photo of your breadboard setup
  - Your measured input impedance, beta, and output impedance
- Part 3 (optional, 4 points extra credit)
  - A photo of your breadboard setup
  - Your measured DC operating point and amplification
- Your lab notebook as usual