Lab 3b: BJTs - Fixing AC Gain, Capacitor Sizing

Introduction

"One who makes no mistakes, never makes anything."
-English proverb

─────────────

Overview

You will alter and complete the design of the BJT amplifier from the last lab to create an AC amplifier and test it.

Lab procedure

1. In the prior lab, you hopefully did not achieve a gain of (15). If you did, with this lab, try for a gain of 30 instead. In this lab, we will alter the circuit to provide the AC gain we desired. See the schematic below, which represents the configuration of the altered amplifier. The old R3 has been replaced with the combination of R6 and R7. By adjusting the values of R6, R7 and C3 we will be able to set our gain.
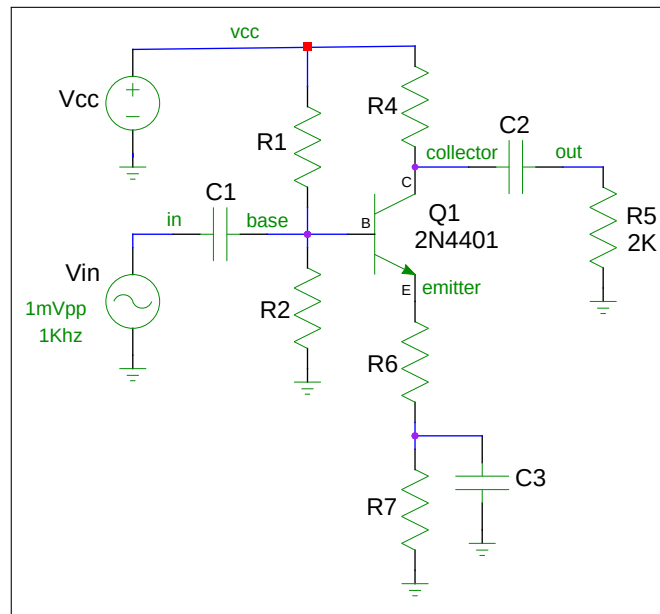

Figure 1: Altered Amplifier Schematic

1

Your altered amplifier should maintain a quiescent V_c of about 0.5Vcc. Draw the new schematic including all component values except for R6, R7, C1, C2 and C3 in your lab notebook.

2. Using the new schematic, determine what values the resistors R6 and R7 should be to maintain the DC Q-point you had from before yet provide the desired gain given that R7 will be bypassed with a capacitive reactance that is near zero ohms at 1KHz.

   Remember that in the small-signal AC model, the load resistor is in parallel with the collector resistor and that the lower end of the unbypassed resistor R6 is at AC ground.

   Given that the reactance of a capacitor is: $X_c = \frac{1}{2\pi FC}$, compute the value of bypass capacitor C3. C3 should have a low reactance at the frequencies of interest relative R6 ohms. If C3's X_c is just a few percent of R6, that's fine. For our purposes, let's also say we are interested in frequencies from 100Hz to 20KHz. We only have a few values of capacitor in lab so your choices are limited. Choose the closest value you can.

   In the same fashion, determine appropriate values for the input and output coupling capacitors. You will need to compute the input impedance to determine C1. C2 is determined by setting its X_c to be a few percent of the load resistor.

3. Download the model file 2n4401.mod to a working area for lab3b. Modify your spice file from lab3 to create a new spice file that includes C1, C2, C3, R6, R7 and a 1mvpp, 1KHz AC signal source.

   Using ngspice, compute the voltage gain. You will have to use the `tran` and `plot` simulation directives (see diode applications slides) to allow the transient simulation to be run. A synopsis of the commands is shown below:

```
*transient analysis
* tstep, tstop, [tstart]
tran 20u 5m ; transient (time domain) analysis
* plot every 20uS for 5mS
plot v(in) v(out) ; plot AC voltages
```

   Record your measured input and output voltages. Did you meet your expected gain? Paste the plot created into your lab notebook. It should show both input and output waveforms. Be sure to probe the output signal after the output coupling capacitor. This will allow you to get both input and output waveforms on the same plot.

4. Build your amplifier adding R6, R7, C1, C2, C3. Apply the input signal using the function generator. Measure input and output amplitudes. From those determine your gain. Record your data and put a picture of the oscilloscope display in your lab notebook.

5. (If you are curious...) Look at the small signal frequency response by commenting out the transient analysis steps in your spice simulation and replacing with:

```
*ac small signal freq response
ac dec 10 1 200meg ; small signal analysis; 10 pts/decade, 1 hz to 200mhz
```

```
plot 20*log10(vm(out)/vm(in)) ylabel '20*log(v(out)/v(in))'
```

Also at the top of your netlist you will need to use a slightly different source to be specified; one without a fixed frequency. Remove your old transient source and replace with:
```
Vin in gnd ac=0.1 ; for swept source
```

Your lab notebook should have the following:

- The schematic of your altered amplifier with all values shown.

- Any calculations you used in determining the values of R6, R7, C1, C2, C3

- The spice file that you used to simulate the final circuit with caps included

- The spice plot of input and output signals

- The oscilloscope plot of input and output signals

- The gain of your amplifier noting any differences between calculated and observed gain.