Lab 9
BJT Two-stage amplifiers

Pre-Lab

1. Design the amplifier in step 1. Hint: $A_{vo} \approx -\frac{R_C}{R_E}$. Start by choosing the output bias point, V_C, to make it saturate symmetrically.

2. Design the amplifier in step 5.

3. Design the amplifier in step 6. If you use sensible approximations this is a far quicker task than it appears at first.

In this lab you will design and characterize two-stage amplifiers.

BJT two-stage amplifier: capacitive coupling

In this section you will build a BJT two-stage amplifier with larger gain by combining two smaller-gain amplifiers.

1. Using 0 and 15 V supplies, design a common-emitter with emitter resistance amplifier with a gain of $A_{vo} = -5$ and $I_C \approx 1\,\text{mA}$. The amplifier output should be biased such that it saturates symmetrically (positive and negative output saturation happens at approximately the same input amplitude). Also, the input resistance should be made much larger than the output resistance.

2. Measure the actual small-signal gain, output bias, and verify that it saturates approximately symmetrically.

3. Cascade two such amplifiers, using a capacitor, to create a two-stage amplifier with a gain of $A_{vo} = 25$.

4. Measure the actual small-signal gain, output bias, and positive and negative output saturation levels. Also plot the input/output characteristic in XY mode.

5. **Extra credit:** Build a single-stage common-emitter with emitter resistance amplifier with gain $A_{vo} = -25$. Plot the input/output characteristic in XY mode. Is the linearity noticeably worse than that of the two-stage amplifier?

BJT two-stage amplifier: direct coupling

In this section you will build a BJT two-stage amplifier with direct coupled output and small output resistance.

6. Using ±15 V supplies, design a two-stage amplifier with no capacitive output coupling (but still capacitive input coupling). Here are the requirements

   (a) The first stage should be a common-emitter with emitter resistance and the second stage should be a emitter follower. The input of the second stage should be directly coupled to the output of the first stage, such that the output bias of the first stage correctly biases the second stage.

   (b) The gain should be, $A_{vo} = -10$.

   (c) The output should be biased at ground.

   (d) The input should be coupled through a capacitor.

   Here are some hints

   (a) You need to make $R_{C1} \approx 10\,R_{E1}$ and have $V_{C1} = V_{B2} \approx 0.7\,\mathrm{V}$ in order to have the emitter follower output at ground.

   (b) Use an emitter resistor, R_{E2}, to bias the output stage. R_{E2} will also modify the expressions for the input and output resistances in that R_{E2} is parallel to r_o.

   (c) Use sensible approximations, such as $A_{vo} = -\frac{R_C}{R_E}$ (for the common-emitter with emitter resistance), $r_e \ll R_E$, $A_{vo} = 1$ (for the emitter follower), etc, to simplify the expressions for gains and resistance to allow you to quickly converge on the correct design.

7. Build the circuit and verify that the output is biased at ground.

8. Measure the small-signal gain and compare to design specifications.

9. Measure the input and output resistances of the circuit and compare to theory.