

## Lab 10

### BJT Two-stage Amplifier

In this lab you will build a simple two-stage op-amp, and characterize it, then improve its gain by modifying the stated requirements.

#### Pre-Lab

1. Complete step 1.
2. Complete step 2.
3. Decide how you would modify the requirements to increase the gain.

#### Op amp 1

Build and characterize an op-amp using a differential pair stage, biased with  $R_{EE}$ , and a emitter follower output stage with the output biased at zero when the input is also biased at zero. Use  $\pm 15\text{ V}$  supply voltages. Note that because of this biasing the amplifier only works for negative input voltages, and saturates for positive input voltages.

1. Design the op-amp such that  $R_{id} = 10\text{ k}\Omega$ , and  $R_{out} = 25\ \Omega$  (you may use the simple approximation for the output resistance).
2. Derive the actual input and output resistances, the overall gain  $A_{vo} = \frac{v_o}{v_{id}}$ , and the common-mode gain.
3. Measure  $R_{id}$ ,  $R_{out}$ ,  $A_{vo}$ , and the common-mode gain, and compare with theory.
4. Apply feedback to create an inverting amplifier with a gain of 3. Note again that because of the way it is biased it really only functions properly when negative input is applied.

#### Op-amp 2

Change some of the requirements to increase the overall gain,  $A_{vo}$ , then repeat the steps. Get as far as you can, but at least describe which requirements you would modify, and how, to increase the gain.