Lab 8
BJT Single-Stage Amplifiers

In this lab you will build a linear single-stage amplifier and measure transistor amplifier input and output resistances.

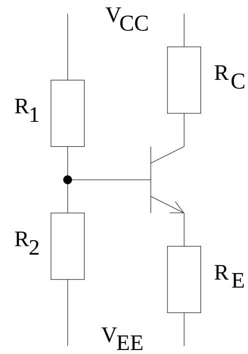
Pre-Lab

1. Design the circuit in step 1. Compute r_π and r_e.
2. Compute the input resistance for step 3 and the frequency to use.
3. Compute the theoretical gain in step 3.
4. Pick a resistor value for step 4.
5. Determine the expected output resistance in step 6.
6. Compute the theoretical emitter follower gain in step 9.
7. Compute the theoretical output resistances in section 9, use it to pick a source resistance for step 10, and compute the output resistance for step 10.

A Linear BJT Common-Emitter Amplifier

In this section we will look at how gain can be traded for linearity in the common-emitter amplifier. You get the highest gain by applying the input voltage directly to the base. But in that case linearity is poor because base voltage and collector current are related through an exponential. If on the other hand the input is coupled through a large resistor to the base the base end of the resistor becomes a virtual ground and the effect is that the source voltage effectively controls the base current. The base current is linearly related to the collector current and thus we expect better linearity. Because the source now has high output resistance the cost of this linearity is reduced gain from source voltage to collector voltage.

1. Build the common-emitter amplifier pictured below. Make $I_C = 1\,\text{mA}$, $V_C = 10\,\text{V}$, and $V_E = 5\,\text{V}$ with $V_{CC} = 15\,\text{V}$ and $V_{EE} = 0\,\text{V}$. Choose R_1 and R_2 small enough that the voltage divider is not affected much by the base current (about 10 times more current through the voltage divider than into the base).



2. Connect the function generator through a large capacitor to the input and apply a small signal of sufficiently high frequency that it is not attenuated by the $R_{\text{in}}C$ filter (verify that the gain is independent of frequency near the frequency you pick).

3. Measure the signal gain and compare to a theoretical prediction. Plot the input/output characteristic in XY mode allowing it to saturate at the ends. Except for the saturated portions, is it very linear?

4. Next insert a resistor (source output resistance) between the function generator and the coupling capacitor. Make the resistor much larger than the input resistance ($R_1||R_2||r_\pi$). Estimate the gain v_c/v_s. Compute v_b/v_s, then i_b/v_s (i_b is through r_π only), then i_c/v_s, and finally v_c/v_s.

5. Apply a input signal, measure the gain, and compare to your prediction. Plot the input/output characteristic in XY mode including saturation at the ends. Is it more linear than before?

Input and Output resistance of the Common-Emitter Amplifier

In this section you will measure the input and output resistance of the common-emitter amplifier. The standard way to do that is to compare the voltage with no source/load resistance to the voltage with some resistance. The reduced voltage with resistance is due to a voltage division.

6. Compute the input and output resistances of the common-emitter amplifier, ignoring the Early effect. Pick resistors of similar size.

7. Measure the input resistance by measuring the output voltage (for a very small input to ensure linearity) with and without the resistance attached to the input, and compare with the theoretical prediction.

8. Measure the output resistance by measuring the output voltage with and without the resistance attached to the output, and compare with the theoretical prediction.

Output Resistance of the Emitter Follower Amplifier

In this section you will measure the output resistance of the emitter follower, whose input is the base and output the emitter. The emitter follower is non-unilateral, which means that the output resistance depends on the source resistance.

9. Using still the same circuit, couple the function generator through a capacitor to the base, and the emitter through a capacitor to a scope probe. Measure the small-signal gain and compare with a theoretical prediction.

10. Connect the function generator directly to the base capacitor. Measure the output resistance. Compare with a theoretical prediction.

11. Now connect the function generator through a large resistor, large enough to change the output resistance. Measure the output resistance again and compare to the theoretical value.