Lab 7
BJT IV Characteristics and common-emitter amplifier

Pre-Lab

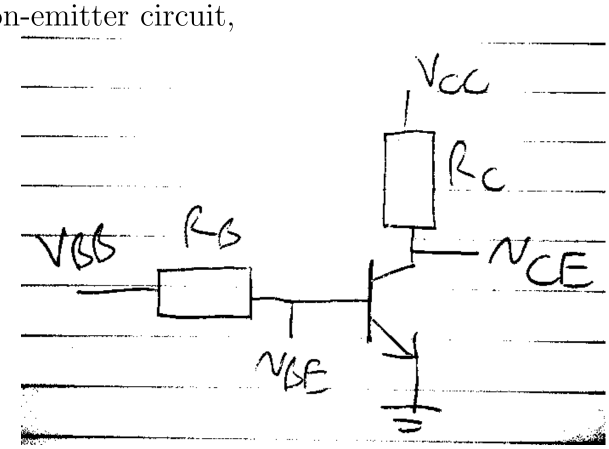
1. Find the data sheets for the 2N3904 and 2N3906 BJT transistors. What is the maximum power dissipation that this component can tolerate? Derive an approximate expression for the power dissipation in the BJT. Note that h_{FE} on the data sheet is what we call β in class.
2. Compute R_B and R_C in step 1.
3. Compute r_e for step 3.
4. Prepare the calculation of the Early voltage in step 5.
5. Pick values for step 7.
6. Compute the theoretical gain in step 9.
7. Pick R_B for step 12.
8. Think about step 16.

In this lab we will look at the IV characteristics of BJTs and build and characterize a simple voltage amplifier.

BJT common-emitter characteristics

In this section you will examine the IV characteristic of a BJT.

1. Build the common-emitter circuit,



choosing R_B for a base current of 0.01 mA when $V_{BB} = 10\,\text{V}$. What do you expect I_C to be? Pick R_C to get $V_{CE} = 5\,\text{V}$ when $V_{CC} = 10\,\text{V}$.

2. What are the actual values of I_B and I_C? What is β? Compare with the data sheet. What is the power dissipation in the BJT?

3. Attach $R_E = r_e$, effectively doubling r_e, and again make $V_{CE} = 5\,\text{V}$ and get I_B, I_C, and effective β again.

4. Map i_C as a function of v_{CE}: attach V_{CC} to the function generator outputting a large-amplitude (for example $10\,\text{V}$) sine wave. Measure v_{CE} with one scope probe and i_C with the other by measuring across R_E. Plot in XY mode. If the signal is noisy try to amplify it with a op-amp (null the circuit), averaging on the scope, or filtering with a capacitor.

5. Estimate the Early voltage from the slope of i_C versus v_{CE}.

6. Repeat steps 4 and 5 for a couple other values of I_B, taking care not to exceed the maximum power dissipation of the BJT.

The common-emitter amplifier

In this section you will measure the gain and linearity of the common-emitter amplifier.

7. Using the same circuit as before, without R_E, connect $V_{CC} = 10\,\text{V}$. Connect the base to a function generator through R_B. Pick values for $V_{BB} \gg V_{BE}$ and R_B such that you get $I_C = 5\,\text{mA}$ (you know β from earlier). Pick R_C to get $V_{CE} = 5\,\text{V}$.

8. Measure V_{CE}, then adjust V_{BB} to get $V_{CE} = 5\,\text{V}$. What is the value of β and how does it compare to what you measured in step 2?

9. Connect AC coupled probes to the input, v_B, and the output, v_C. Plot the AC input, v_b, and output, v_c, together for the smallest input amplitude you can get and compare with a theoretical prediction.

10. Measure the gain for a few larger amplitude inputs up to the point of clipping, and conclude something about the linearity of the gain with input amplitude. You can also plot output versus input in XY mode.

11. Explain what causes the clipping at the top and bottom of the curve by increasing the amplitude to have clipping about 50% of the time and plotting v_{BE} and v_{CE} with v_c.

Capacitive coupling in the common-emitter amplifier

In this section we will bias the amplifier and then capacitively couple the input signal.

12. In the same circuit, connect V_{BB} to V_{CC}, and resize R_B to preserve $I_C = 5\,\text{mA}$.

13. Now couple a signal, v_s, from a function generator to the base through a large capacitor.

14. Again measure the gain for several input amplitudes.
15. How does the gain compare to the previous circuit in which the input was coupled through R_B? Again you may wish to plot in XY mode.
16. How does the linearity compare? Can you explain why one circuit may be more linear than the other?