LAB 4

Transistor Amplifiers

Reading: Malvino: Ch.10 through Ch. 12.

Hayes and Horowitz: Class 4, Lab 4 and worked examples, pp. 90ff and 115ff.

In this lab we experiment with different types of transistor amplifiers using the voltage-divider bias.

1. The Common-emitter Amplifier

a) Starting from the voltage-divider bias of the last experiment, add an input coupling capacitor and a bypass capacitor on the emitter resistor to make a common-emitter amplifier. Calculate the values of the capacitors so that the low-frequency 3 dB point of the amplifier will be between 100 and 200 Hz. Measure the amplification using the channel 1 of the scope to display the input, and the channel 2 for the output. Measure the low-frequency 3dB point. Compare the measured values with what you expected from calculations. Now investigate the input and output impedances.

b) You should have noticed the "barn roof" distortion of the design of part (a). Find a method to reduce the distortion without changing the bias. Measure the effectiveness of your improvement. How is the amplification affected?

2. The Emitter-follower Amplifier

a) Construct the emitter follower circuit shown below in Fig 4.1.

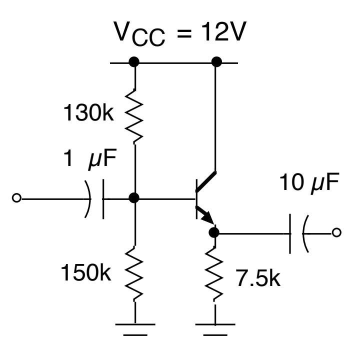

Fig 4.1

b) Calculate the base voltage V_B, the emitter voltage V_E, V_{CE} and the emitter current, I_E. Measure these quantities and compare.

c) Measure the small-signal gain at 1 kHz. Is there any variation in the gain between 100 Hz and 10 kHz? Can you detect any phase shift between the input and output? Try to find the critical frequencies in the high- and low-frequency ranges.

d) Measure output and input impedances. Calculate the power gain. Increase the amplitude of the input signal and determine the onset of distortion, Explain.

3. The Push-pull Output Stage.

a) Build the push-pull emitter follower shown in Fig 4.2. Try to match the NPN/PNP transistor pairs.

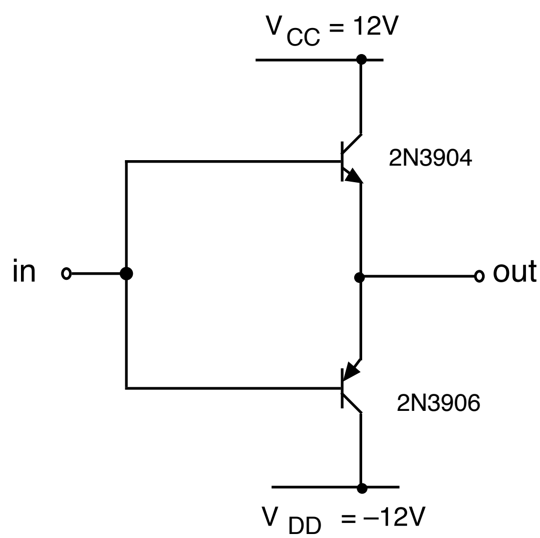

Fig 4.2

b) Explore crossover distortion by driving it with a signal of at least a few volts amplitude.

c) Try to eliminate crossover distortion by inserting diodes or resistors in the bias circuit.

4. (OPTIONAL) The Darlington Pair

a) Design and build an emitter follower using the Darlington pair connection of Fig 4.3.

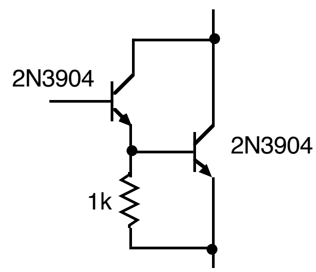

Fig 4.3

b) Measure current gain and input and output impedance.

c) Can you explain the function of the 1 kΩ resistor? (Hint: See Horowitz and Hill.)

Homework

1. Determine the capacitor values for use in part 1(a).

2. Calculate the voltages and currents asked for in the emitter follower of part 2(b). Also calculate the small-signal voltage gain and the input and output impedances of the emitter follower. If the emitter-follower is driving an external load, what load impedance yields maximum power transfer to the load? Calculate the ratio of the maximum power transferred to the load to the input power. This is the power gain.

3. (optional) Design an emitter follower using the Darlington Pair. Try to make the input impedance as high as practicable. Calculate current gain, input impedance and the output impedance.

Hints: The critical frequency is the frequency at which the effect of the capacitor is to reduce the voltage by a factor of $\sqrt{2}$. If you choose the two capacitors so that this frequency is the same (e.g., 150 Hz) for both the input stage and the bypass, the output at this frequency will be reduced by a factor of $(\sqrt{2})^2 = 2$.

For the bypass capacitor it is *not* R_E that you need to use. Draw the a.c. equivalent circuit and derive a formula for v_E/v_B. Without the capacitor this ratio will be about 1 at all frequencies. Choose the capacitor so that the ratio is at the critical frequency.