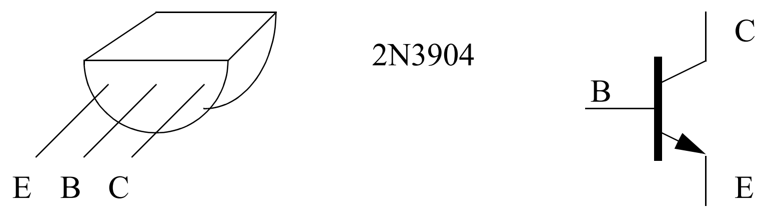
Physics 375, Laboratory 11
Transistor Amplifiers

Overview

The purpose of these experiments is to measure AC signal amplification, input and output impedance using a common-emitter amplifier and a source-follower amplifier.

Background

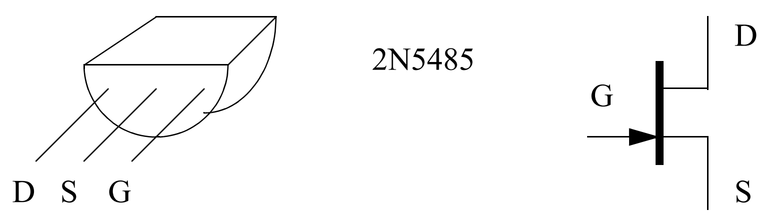
The 2N3904 is a general purpose npn transistor. The 2N3904 comes in a TO-92 plastic case with leads for emitter, base and collector.



The 2N3904 has maximum ratings as follows:

$V_{CE} < 40$ V
$V_{CB} < 60$ V
$V_{EB} < 6.0$ V
$I_C < 200$ mA
$P = I_C V_{CE} < 625$ mW

A junction field effect transistor (JFET) is made from a junction of a p-type and n-type semiconductor, but the junction is used to control the conductance in one of the semiconductor layers. In many ways a JFET behaves like a bipolar junction transistor with the drain, source and gate equivalent to the collector, emitter and base. The 2N5485 is an n-channel JFET and comes in a TO-92 plastic case with leads for drain, source and gate.



The 2N5485 has maximum ratings as follows:

$V_{DG} < 25$ V, $-V_{GS} < 25$ V
$I_D < 30$ mA, $P = I_D V_{DS} < 300$ mW

1. Signal Amplifier

Build the circuit in figure 1 using a 2N3904 transistor.

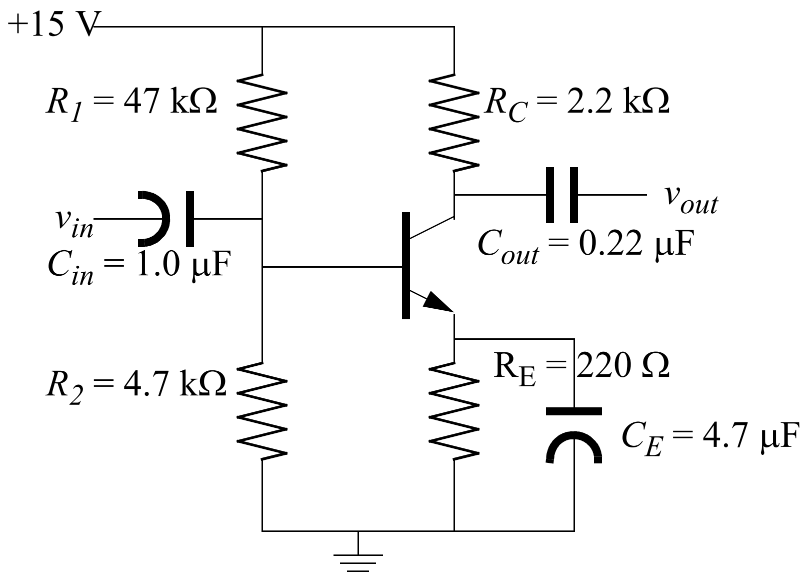


Figure 1: Common Emitter Amplifier

Build the circuit and measure V_B, V_C and V_E and compare to the expected values for DC operation. Use a sine wave generator (no DC offset) for v_{in} and an oscilloscope to measure both v_{in} and v_{out}. Measure the gain A vs. frequency f for f = 50 Hz, 100 Hz, 200 Hz, 500 Hz, 1 kHz, 2kHz, 5 kHz, 10 kHz, 20 kHz and 100 kHz. Compare the gain to the expected value

$$A = \frac{-\beta R_C}{h_{ie} + Z_E} \qquad Z_E = \frac{Z_{R_E} Z_{C_E}}{Z_{R_E} + Z_{C_E}}$$

Remove the emitter bypass capacitor C_E and measure gain vs. frequency again.

2. Amplifier Impedance

Measure the impedance of the amplifier of figure 1 by creating a voltage divider and measuring the change in signal. To measure the input impedance, place a known resistor R_S in series before the input capacitor and operate the function generator at 1 kHz. The gain in the signal will change according to the following formula:

$$A' = \frac{Z_{in}}{R_S + Z_{in}} A \qquad Z_{in} = \frac{1}{A/A' - 1} R_S$$

Try different resistors to get a good measure of the gain. The best result will occur when R_S is about equal to Z_{in} so that A/A' is about 2. To measure the output impedance place a known resistor R_L from the output to ground to form a voltage divider. The gain in the signal will change:

$$A' = \frac{R_L}{R_L + Z_{out}} A \qquad Z_{out} = (A/A' - 1)R_S$$

The input impedance should be roughly the parallel impedance of the base bias resistors and h_{ie}. The output impedance should be roughly the parallel impedance of the collector resistor and $50h_{ie}$. How well does your circuit compare to the expected impedance?

3. FET Follower

Build the circuit in figure 2 using a 2N5485 transistor.

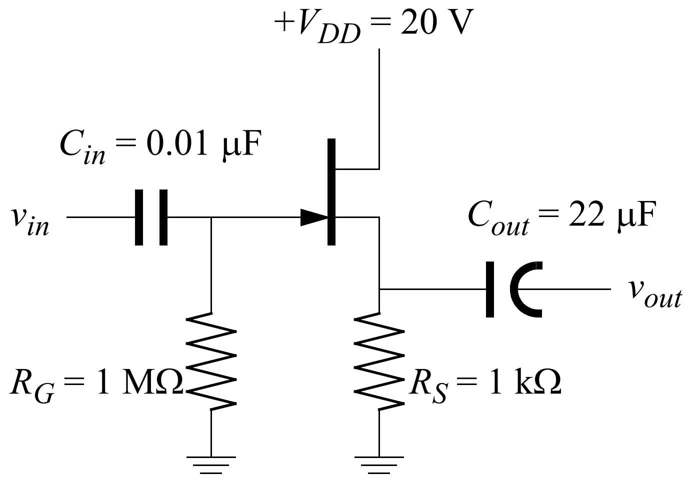


Figure 2: Source Follower Amplifier

Measure V_G and V_S, calculate I_D and compare to the expected values for DC operation. Use a sine wave generator (no DC offset) for v_{in} and an oscilloscope to measure both v_{in} and v_{out}. Measure the gain A vs. frequency f for f = 50 Hz, 100 Hz, 200 Hz, 500 Hz, 1 kHz, 2kHz, 5 kHz, 10 kHz, 20 kHz and 100 kHz. Measure the input and output impedance of the circuit using the method of part 2.