EE 3310L/5310L · Electronic Devices and Circuits Laboratory

Lab 5: Common-Emitter NPN Voltage Amplifier

Purpose

The purpose of this lab is to construct and test a simple common-emitter voltage amplifier using a 2N3904 NPN bipolar junction transistor. Due to capacitive coupling at the input and output, this amplifier is only useful for AC signals and not DC. Nevertheless, it's a widely-used circuit and the basis for many, many more circuit topologies.

We will analyze the circuit in stages: first the DC operating point; then the amplifier in the open-loop condition; and finally the amplifier with degenerative emitter current feedback, which we have not analyzed in class yet but will when we explore two-port networks and negative feedback. Amplifier gain and frequency response will be measured in both the feedback and non-feedback conditions.

Procedure

DC Circuit

1) Select a 2N3904 NPN transistor and use your DMM to measure and record its h_{FE}. Discard it if its value is less than 100.

2) Build the following circuit. Measure and record V_B, V_E, and V_C. Verify the following approximate values before proceeding: V_B = 1.3 V, V_E = 0.6 V, and V_C = 11.1 V, for a quiescent current of about 1.8 mA.

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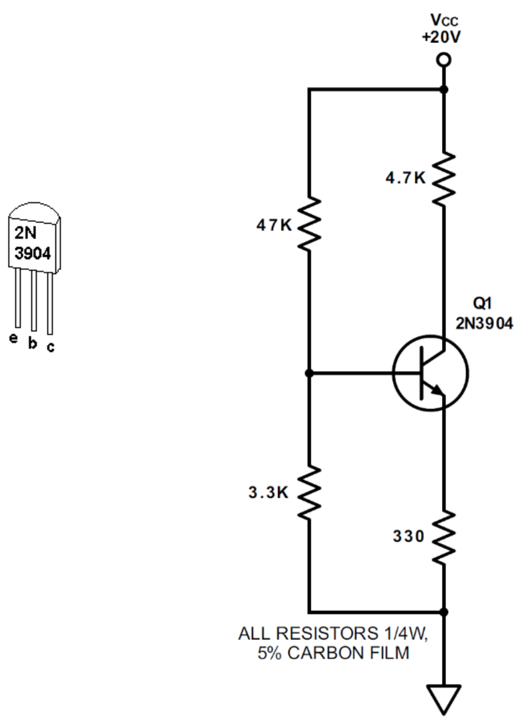
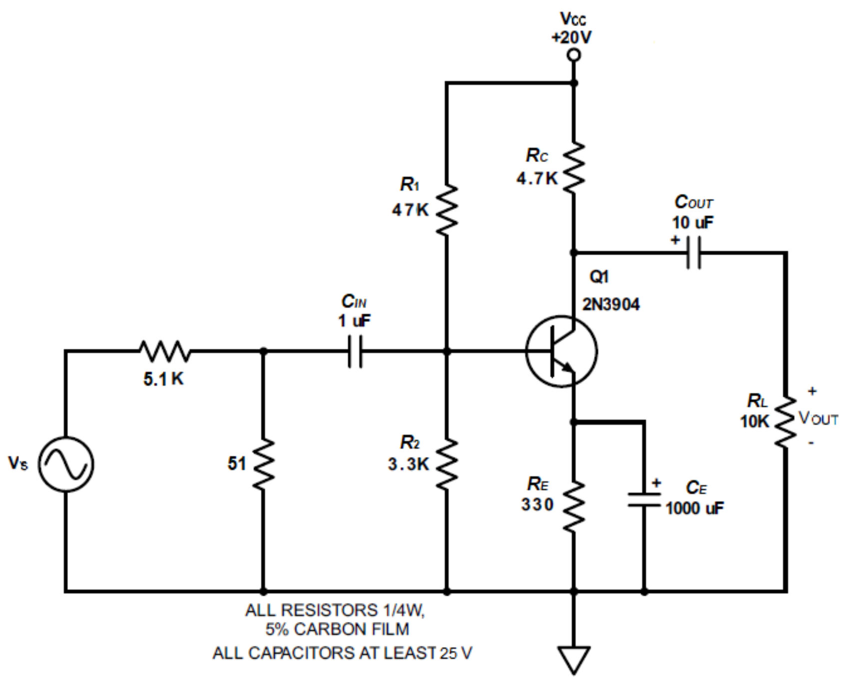


Amplifier Circuit

3) Add components to make a complete common-emitter voltage amplifier circuit, as shown below. <u>Watch the polarities of the output and emitter capacitors, as they are electrolytic and must be installed correctly.</u> Connect the signal generator where V_S is indicated. <u>Use x1 oscilloscope probes</u>; connect channel 1 of the oscilloscope to the function generator and channel 2 to the output of the amplifier (V_{OUT}).



Note that a voltage divider has been placed between the signal generator and amplifier input. Due to the very high open-loop gain of the amplifier, it is sensitive to extremely small-magnitude signals, so attenuating the signal generator's output by 40 dB as shown helps to make the adjustment less touchy. The values have been chosen such that the Thévenin resistance of the attenuated signal is approximately 50 Ω like the signal generator itself. Attenuators such as these are sometimes called *pads*.

4) Set the signal generator to 1 V_{P-P}, 1 kHz sine and verify this amplitude on the oscilloscope. Display both channels simultaneously; **the output waveform should be an inverted sine wave**.

5) **Measure and record the peak-to-peak output voltage shown on the oscilloscope. Use it to calculate the 1-kHz gain of the amplifier by $A_V = (V_{OUT}/V_S)$. Also compute A_V(dB).** <u>Don't forget to divide the observed V_S by 100, as this is the actual signal amplitude at the input of the amplifier due to the input pad!</u>

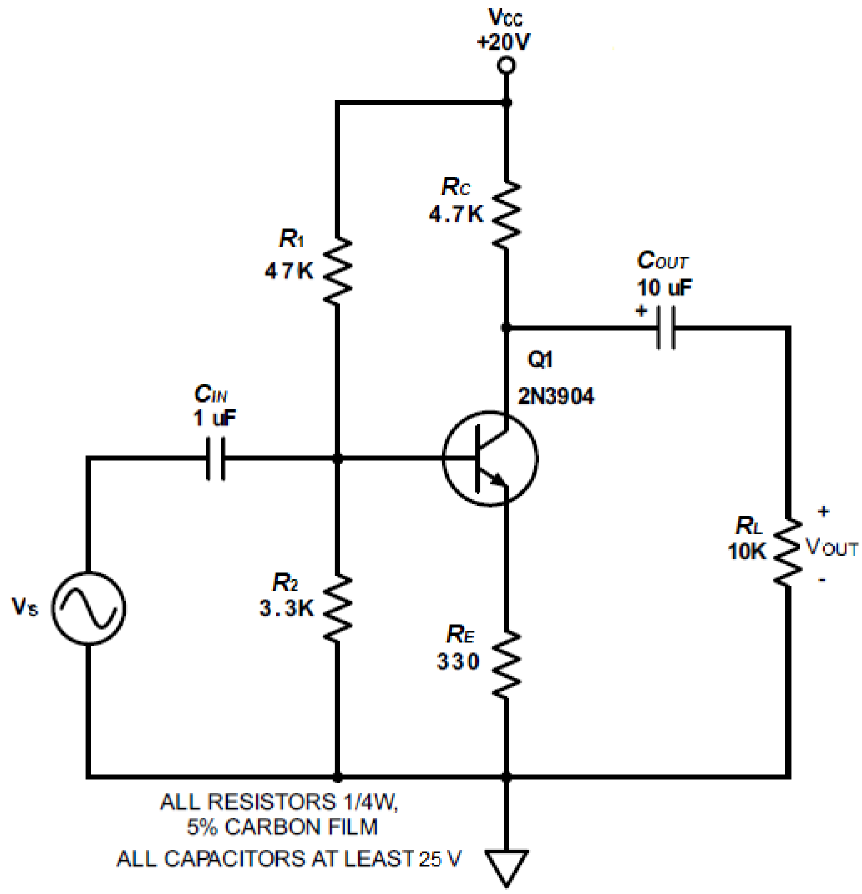
6) Increase the frequency of the signal generator until the output has decreased 3 dB (i.e., the peak-to-peak voltage times 0.707). **Record the frequency; this is the upper cutoff frequency, f_H.**

7) Now <u>decrease</u> the frequency of the signal generator (below 1 kHz) until the output drops by 3 dB. **Record the frequency; this is the lower cutoff frequency, f_L.**

8) Return the signal generator to 1 kHz. **Increase the amplitude until the output waveform is visibly clipped; record the maximum peak-to-peak output voltage at clipping.** Return the amplitude to 1 $V_{P\text{-}P}$.

Amplifier Circuit with Emitter Feedback

9) Remove the 1000-µF emitter capacitor and input attenuator, as shown:



Repeat steps (5) through (8). Gain and frequency response should be quite different because the absence of the emitter capacitor has created a degenerative feedback loop; more on this in a subsequent portion of the class. Verify that the gain at 1 kHz is approximately $(R_C \| R_L)/R_E$.

Postlab

1) **Analytically determine the DC operating point, gain, and upper and lower cutoff frequencies for the common-emitter amplifier.** Don't worry about the amplifier circuit with degenerative feedback. Show all work.

2) Simulate the amplifier using Multisim to determine the DC operating point, gain, and upper and lower cutoff frequencies.

3) Compare simulated, experimental, and analytical values.