Analog Elektronik IE1202 - Home laboratory 5

Student Name:

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1 Introduction

This laboratory consists of 3 tasks related to single stage amplifier stages built with bipolar junction transistors (BJT). The objective of this lab is that you get familiar with typical transistor biasing techniques and basic amplifier configurations. You will concentrate in the design, simulation, construction, and measurement of a common-emitter amplifier, a common-collector (voltage buffer) amplifier, and a Darlington based voltage buffer.

2 Common-Emitter Amplifier

2.1 Circuit Theory

Fig. 1 shows a typical connection of a common-emitter amplifier which is built by using a NPN transistor BC547C ($\beta \approx 500$ and $V_{AF} = 25V$). This amplifier is intended to amplify sinusoidal voltage signals in the range of 1mV to 10 mV in the frequency band 1 kHz - 100 kHz. Your task is to dimension the components of this circuit so that it will provide a voltage gain $A_V > 50$ at room temperature. Calculate the DC operating point, voltage gain, input impedance, and output impedance. Append your hand calculations at the end of this lab. Revelant theory is available in chapter 11.9, pp. 344-349.

2.2 Circuit Simulation

Open QUCS-S and set up a schematic like in Fig. 1. Replace the values that you calculated in the previous subsection and run a DC operating point simulation. Confirm that the DC operating point is what you calculated. If it is not, then you have to find why and correct your circuit. Run AC and transient simulations to confirm correct operation of the amplifier. Take a screenshot of the simulations including AC gain, and transient waveforms (input and output signals). Append your screenshots to the end of this lab.

Question: how is the gain affected if C_1 is removed?

2.3 Circuit Construction and Measurements

Mount the circuit of Fig. 1 on the breadboard (use the resistor values that you simulated in the previous subsection). Power the circuit and measure the operating point. If the voltages differ substantially, then you need to troubleshoot your circuit (check that resistor values and connections are correct). Connect the AWG to the input, set up a 10 mV, 1 kHz sinusoidal signal and measure the output voltage. Is the measurement in agreement with the simulation? Append a screenshot of your measurement to the end of this lab. Remove C_1 and repeat the measurement. Is the measured gain what you expected? Append a screenshot.

3 Common-Collector Amplifier (Voltage buffer)

3.1 Circuit Theory

Fig. 2 shows a typical connection of a common-collector amplifier which is built by using a NPN transistor BC547C ($\beta \approx 500$ and $V_{AF} = 25V$). This amplifier is intended to buffer sinusoidal voltage signals in the range of 100 mV - 1V in the frequency band 1 kHz - 100 kHz from a voltage source with a source resistance of 1 kΩ to a load resistance of 100 Ω. Your task is to dimension the components of this circuit. Calculate the DC operating point, voltage gain, input impedance, and output impedance. Append your calculations at the end of this lab. Relevant theory is available in chapter 11.6 pp. 328-332.

3.2 Circuit Simulation

Open QUCS-S and set up a schematic like in Fig. 2. Replace the values that you calculated in the previous subsection and run a DC operating point simulation. Confirm that the DC operating point is what you calculated. If it is not, then you have to find why and correct your circuit. Run AC and transient simulations to confirm correct operation of the amplifier. Take a screenshot of the simulations including AC gain, and transient waveforms (input and output signals). Append your screenshots to the end of this lab.

3.3 Circuit Construction and Measurements

Mount the circuit of Fig. 2 on the breadboard (use the resistor values that you simulated in the previous subsection). Power the circuit and measure the operating point. If the voltages differ substantially, then you need to troubleshoot your circuit (check that resistor values and connections are correct). Connect the AWG to the input, set up a 1 V, 1 kHz sinusoidal signal and measure the output voltage. Is the measurement in agreement with the simulation? Append a screenshot of your measurement to the end of this lab.

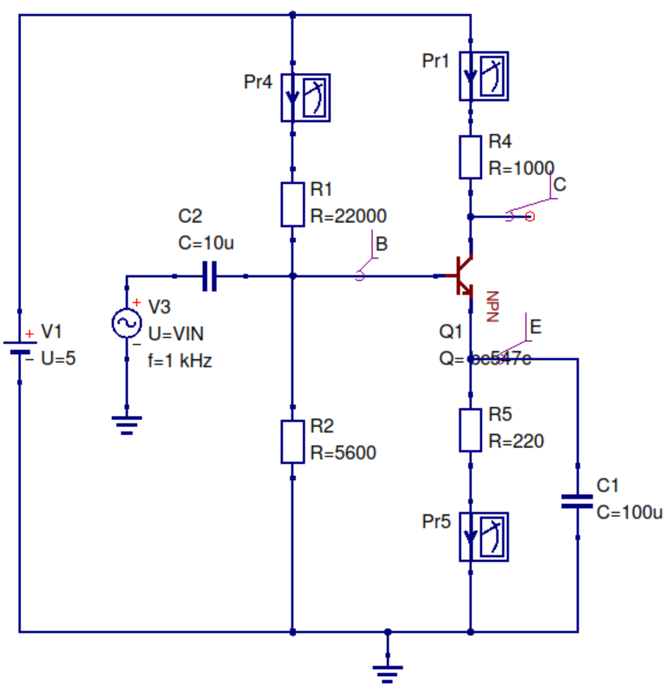

Figure 1: Common-Emitter Amplifier

4 Darlington Voltage buffer

4.1 Circuit Theory

The common-collector amplifier in the previos section has difficulties when handling small loads since its input impedance deteriorates, and therefore its A_V is quite lower than 1. In these cases, it may beneficial to use a Darlington stage. Fig. 3 shows a typical connection of a Darlington buffer which is built by using a NPN transistor BC547C ($\beta \approx 500$ and $V_{AF} = 25V$). This amplifier is intended to buffer sinusoidal voltage signals in the range of 100 mV - 1V in the frequency band 1 kHz - 100 kHz from a voltage source with a source resistance of 1 kΩ to a load resistance of 33 Ω. Your task is to dimension the components of this circuit. Calculate the DC operating point, voltage gain, input impedance, and output impedance. Append your calculations at the end of this lab. Relevant theory for Darlington connection is available in chapter 11.11, pp. 355-356.

4.2 Circuit Simulation

Open QUCS-S and set up a schematic like in Fig. 3. Replace the values that you calculated in the previous subsection and run a DC operating point simulation. Confirm that the DC operating point is what you calculated. If it is not, then you have to find why and correct your circuit. Run AC and transient simulations to confirm correct operation of the amplifier. Take a screenshot of the simulations including AC gain, and transient waveforms (input and output signals). Append your screenshots to the end of this lab.

4.3 Circuit Construction and Measurements

No circuit construction or measurement needed for this part.

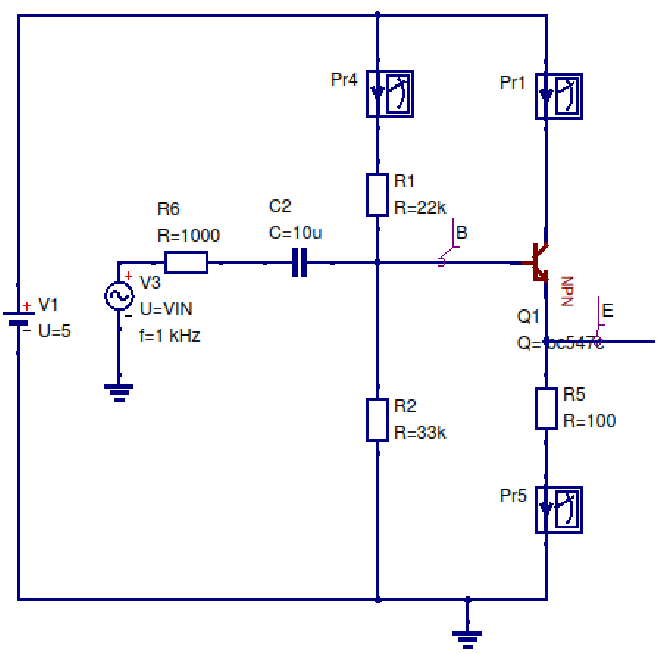

Figure 2: Common-Collector Amplifier

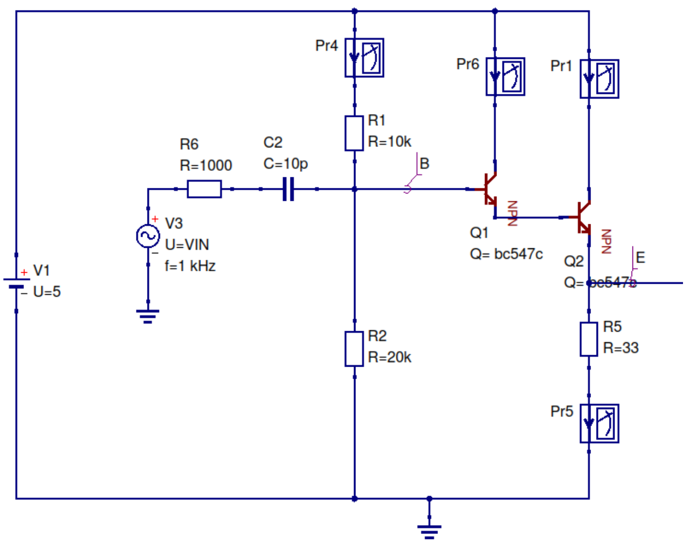

Figure 3: Darlington buffer

5 Comments on the laboration

Here you can give as much feedback as possible on this lab. How long time did it take you to complete this lab? Did you find this lab useful to reinforce underlying concepts such as biasing bipolar transistors and single-stage amplifier gain?