McGill

Microelectronics ECSE 335

Laboratory No. 2

Design and Verification of Single-Transistor BJT Amplifiers with Voltage and Current Source Biasing

Purpose:

Design, simulate and characterize the operation of a single-transistor BJT amplifier circuits through a transistor-level simulator. Use any one of the many freely-available SPICE tools such as PSPICE, LTSPICE or TINA-TI.

Equipment Required:

a. Computer
b. SPICE Simulator (student choice)

Single-Stage Amplifier Circuits

The most fundamental element of electronics is the single-transistor amplifier circuit. In its most general form, Figure 2.1 illustrates the three ways in which to bias and inject a signal into a single npn transistor. The signal is represented by a voltage source. As a result of the manner in which the signal is injected and the transistor is biased, these three configurations are identified as common-emitter (Fig. 1(a)), common-base (Fig. 1(b)) and common-collector (Fig. 1(c)). In the case of the common-emitter (CE) and common-base (CB) amplifier, they are biased using three independent sources, V_B, V_E and I_B. In the case of the CE amplifier, the signal is injected into the base terminal whereas the CB amplifier has the signal injected into the emitter terminal. The common-collector (CC) amplifier, however, is biased using independent sources V_B, V_{CC} and I_B and the signal is injected into the base terminal.

Figure 2.2 illustrates the complementary amplifier arrangement constructed using a single pnp transistor and three independent voltage and/or current sources for biasing.

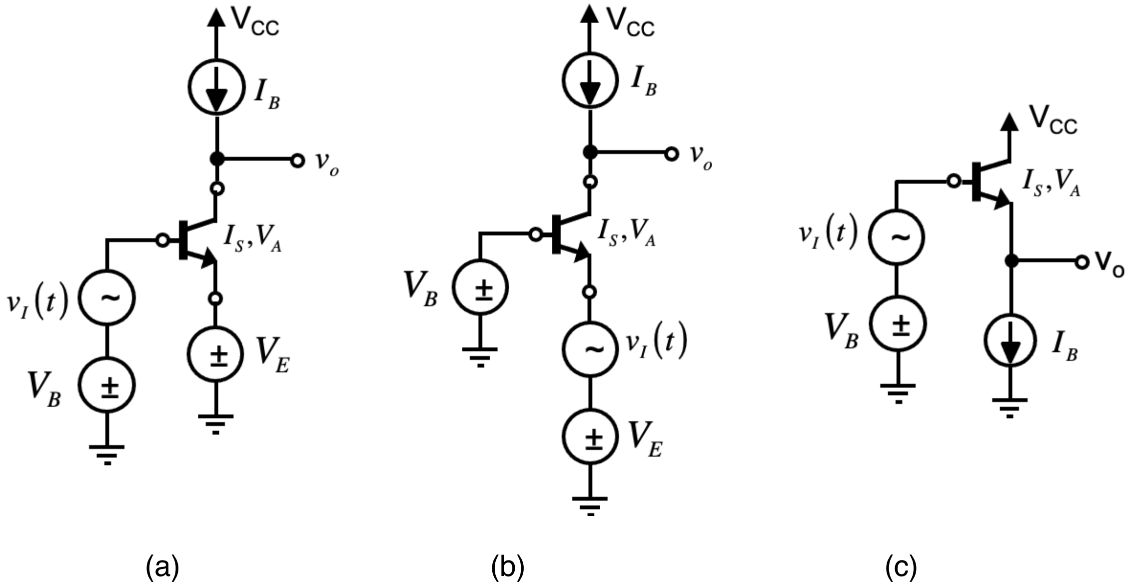


Figure 2.1: Single-transistor npn amplifier configurations using a generalized biasing arrangement: (a) common-emitter, (b) common-base, and (c) common-collector.

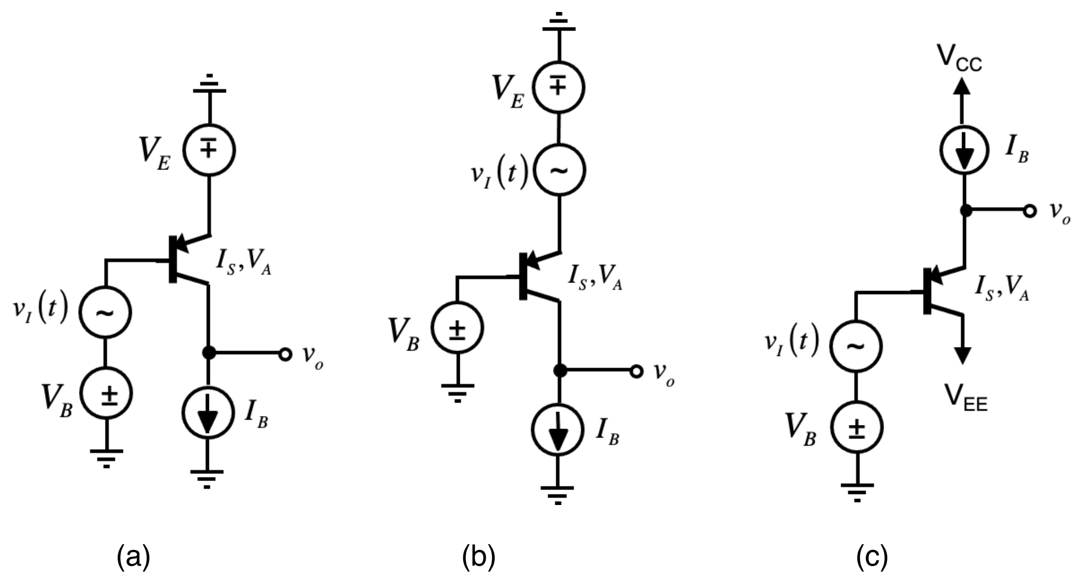


Figure 2.2: Single-transistor pnp amplifier configurations using a generalized biasing arrangement (a) common-emitter, (b) common-base, and (c) common-collector.

The objective of this laboratory is to design, simulate and characterize the CE, CB and CC amplifier configurations.

Write-Up Requirements:

A good laboratory report should contain a **brief** description of what the experiment was about, including circuit diagrams, and what you did, your data, your results, and anything else called for in the assignment, such as questions inserted in the laboratory description. Answers to these questions require observations that need to be made at the time you do the experiment.

The laboratory report should be written using the IEEE paper style consisting of a **double-column single-space format**, and must adhere to the following when necessary:

1. Title page - Title of the assignment/project, authors' name, and course name.
2. Abstract - Abstract of the assignment/project report.
3. Introduction
4. Main body of the assignment/project report including figures.
6. Conclusions
7. References
8. Appendices

Preparation/Experiment

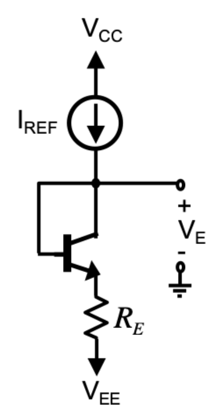
This experiment does not involve any bench work involving physical instruments and equipment. Rather, this exercise is meant to explore your design choices and its impact on the operation of a circuit using a simulator. In your report, please include all design details together with simulation results supporting your conclusions as described below.

NPN CE Amplifier:

1. Establish the biasing of the CE amplifier circuit shown in Fig. 2.1(a) such that an input signal of 1 mV peak-to-peak having a frequency of 1 kHz is connected in series with a base voltage of 2 V and that the collector terminal voltage is set to 5.0 V. Assumed that the transitor is of the MPS3704 type and that the current source has an equivalent Norton resistance of 100 kΩ. What peak-to-peak output voltage results. What voltage gain results? What voltage gain results if the transistor is replaced by a 2N2222A npn type transistor. *How does these results compare with the expected theoretical results?*

2. If the emitter voltage source found above in step 1 above is replaced by a resistor so that the emitter voltage of the transistor remains at this voltage, what voltage gain results when either the MPS3704 and 2N2222A transistors are used? *How does these results compare with the expected theoretical results?*

3. Repeat step 2 but this time use a voltage reference circuit seen in Lab 1 (also shown to the right) involving a diode-connected transistor and series-emitter resistor: *How does these results compare with those found from step 2? Why?*



NPN CC Amplifier:

4. Design the CC amplifier circuit shown in Fig. 2.1(c) such that an input signal of 100 mV peak-to-peak having a frequency of 1 kHz is connected in series with a base voltage of 5.0 V and an emitter current of 10 mA. Assumed that the current source has an equivalent Norton resistance of 100 kΩ. The collector terminal is to be connected to a 10 V voltage supply. What is the input-output voltage gain of the amplifier when either a MPS3704 or 2N2222A npn-type transistor is used. Perform a transient analysis and observe the output signal. *How does these results compare with the expected theoretical results?* Use the small-signal parameters generated by the .OP command in Spice for each device.

5. What is the expected input and output small-signal resistance of this amplifier from part (4) as determine by simulation and *how does it compare with the theoretical results?* Make use of the Transfer Function analysis command in Spice.

6. Design a modified CC amplifier that is biased using an input base voltage of 5.0 V such that its output terminal voltage is set to 1.0 V when biased at 10 mA current level. Make use of a resistor in series with the emitter terminal of the MPS3704 transistor and the output terminal of the amplfiier to create the desired output voltage level of 1.0 V. Assumed that the current source has an equivalent Norton resistance of 100 kΩ. Confirm your results by running a transient analysis that displays both the input and output signals of this amplifier when a 10 mV input signal is applied. What is input and output small-signal resistance of this amplifier? *Discuss your results in your report.*

PNP CB Amplifier:

7. Design the CB amplifier of Fig. 2.2(b) using a 2N2907 pnp-type transistor. Set the emitter terminal voltage to 8.0 V, the base voltage to 7.3 and set the collector current such that that the collector terminal voltage is set to 2.5 V. Assumed that the current source has an equivalent Norton resistance of 50 kΩ. Using an input signal of 1 mV peak-to-peak having a frequency of 1 kHz, provide a plot of the transient input-output response and check its voltage gain. *How does these results compare with the expected theoretical results?* Use the small-signal parameters generated by the .OP command in Spice for each device.

8. What is the expected input and output small-signal resistance of this amplifier as determine by simuylation and *how does it compare with the theoretical results?*

This concludes this lab.